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Volume 33,2

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IN CELEBRATION
OF
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ITS IMMEASURABLE CONTRIBUTIONS TO BOTANY IN SOUTH AFRICA AND FURTHER AFIELD

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Bothalia 33,2: 141–143 (2003)

Jamesbrittenia bergae (Scrophulariaceae), a distinctive new species from Limpopo, South Africa

P. LEMMER*

Keywords: *Jamesbrittenia* Kuntze, Limpopo [Northern Province], Manuleae, new species, Scrophulariaceae, Thabazimbi

ABSTRACT

Jamesbrittenia bergae P.Lemmer is a new species from the Farm Brakvallei near Thabazimbi in Limpopo [Northern Province]. Large, medium-textured, bright scarlet flowers with yellow throats are borne singly in upper leaf axils; the flowering branches, although terminal, do not form elongated racemes; leaves are greyish green, coarsely serrated. It grows in full sun on ferricrete outcrops.

INTRODUCTION

This distinctive new species was discovered by Mr A.S. Berga, nurseryman and keen indigenous plant grower, on the Farm Brakvallei near Thabazimbi in February 2002 (Figure 1). Photographs and specimens were taken for identification purposes. Literature studies and specimens examined at the C.E. Moss and Bolus herbaria pointed us to the genus *Jamesbrittenia*. The use of the *Jamesbrittenia* key in *The Manuleae. A tribe of Scrophulariaceae* (Hilliard 1994), however, could not aid identification.

A pressed flowering specimen of one of the plants grown from seed collected in the field, was sent for comment to Dr O.M. Hilliard, Royal Botanic Garden, Edinburgh, who is the authority on the taxonomy of the genus. She replied that the plant was unknown to her, but that it might be a hybrid, provided that possible parents occurred in the area. A thorough search at the original locality, however, revealed only *Jamesbrittenia burkeana* (Benth.) Hilliard. In view of the lack of putative parents and the fact that seeds of the plants germinated prolifically with the progeny exactly resembling the original plants, I maintain that this is, indeed, a new species.

Jamesbrittenia bergae *P.Lemmer*, sp. nov., species distincta statim floribus pro ratione magnis, splendide coccineis recognita; fortasse *J. accrescenti* (Hiern) Hilliard affinis, sed ab illa colore dissimile florum, tubo corollae 12–18 mm longo (non 18–25 mm longo ut in *J. accrescente*). textura loborum corollae media, apicibus plerumque retusis margineque non colore dilutiori (textura *J. accrescentis* crassa, marginibus pallidis tenuisque, apicibus ± rotundatis), ovario glabro (in *J. accrescente* minute glanduloso-puberulo), capsulis 4–7 mm × 2–3 mm (non 7–10 mm × 3.5–4.5 mm ut in *J. accrescente*), et distributione geographico (in ditione Thabazimbi, non montibus Zoutpansberg dictis vel terra alta provinciae Mpumalanga dictae), distinguitur.

TYPE.—Limpopo, 2427 (Thabazimbi): Farm Brakvallei, southern foothills of Berg van Winde, on ferricrete outcrops, southern aspect, 1 060 m, (–CB), *S.E. Strauss 808* (PRE, holo.!; E!, PRU!).

Multistemmed shrublet up to 200 mm high, with perennial rootstock; stems ± erect or spreading; most parts strongly and pleasantly herb-scented when crushed; plants very floriferous. *Leaves* alternate, occasionally opposite towards base of stems, spreading, greyish green; lamina elliptic to obovate, (5–)8–15(–25) × (3–)6–10(–15) mm, tapering towards base, apex ± obtuse, margin coarsely serrate to irregularly lobed, both surfaces with glandular-hispid hairs, ± 0.3 mm long, and with evenly distributed, glistening glands, veins impressed above, raised below; petiole $^1/_4$–$^1/_3$ total leaf length. *Flowers* solitary in upper leaf axils, terminal flowers being the youngest. *Pedicels* usually 10–20 mm long. *Calyx* divided almost to base; tube 0.5–1.0 mm long; lobes 5.5–8.0 × 0.8–1.5 mm, oblong, apex subacute to rounded, densely covered with glandular hairs ± 0.3 mm long and with scattered glistening glands. *Corolla*: tube 12–18 × 0.8–1.2 mm, measured midway between base and limb, but ± cylindrical, abruptly expanding and geniculate near apex, with multicellular glandular hairs, 0.7–1.0 mm long, and scattered glistening cells (Figures 2A; 3); well-bearded on outside of expanded part; mouth rounded, limb nearly regular, 16.5–25.0 mm across lateral lobes; lobes spreading, broadly ovate, 8.2–11.5 × 8–11 mm, base cuneate, apex distinctly retuse, rarely ± rounded, outside with few glandular hairs and scattered glistening glands, especially towards base, inside glabrous; lobes medium-textured, brilliant scarlet above, dull whitish below, without a thin-textured, pale margin; throat 3–4 mm diam., bright yellow, with transverse, V-shaped band of hairs on inside not extending onto base of anterior lip. *Stamens*: posticous filaments ± 0.7 mm long, posticous anthers ± 0.8 mm long; anticous filaments ± 1.2 mm long, anticous anthers ± 1.2 mm long; all filaments distally slightly bearded with clavate hairs; anthers included. *Ovary* 2–3 × 0.8–1.5 mm, glabrous; style 10–15 mm long; stigma ± 1 mm long, appearing simple, though minutely bifid, included; nectary not distinct, apparently comprising sterile basal $^1/_4$ portion of ovary, no nectar secretion observed. *Capsules* 4–7 × 2–3 mm, slightly shorter, as long as, or just protruding from persistent calyx lobes, glabrous (Figure 2B). *Seeds* ± elliptic to unevenly shaped (Figure 2C), ± 0.5 mm long, grey-

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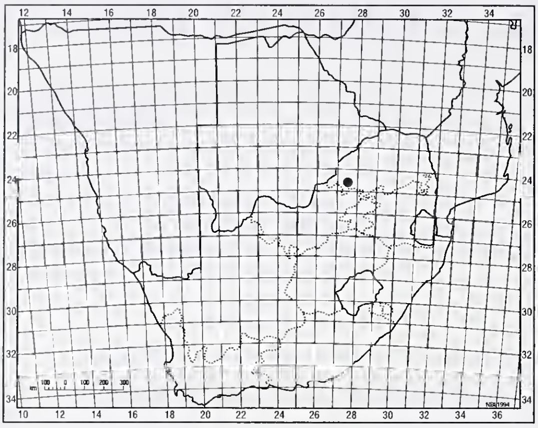

FIGURE 1.—Distribution of *Jamesbrittenia bergae* P.Lemmer in Limpopo [Northern Province].

brown; testa with polygonal cells clearly visible, arranged in ± longitudinal rows, outer periclinal walls collapsed inwards forming a shallow pit, radial walls smooth (Group1a *sensu* Hilliard 1994: 85).

The glandular pubescence and the medium-textured corolla lobes are reminiscent of *Jamesbrittenia candida* Hilliard, the habit and general vegetative morphology of *J. accrescens* (Hiern) Hilliard and the flower shape with their arrangement towards tips of stems of *J. grandiflora* (Galpin) Hilliard and *J. macrantha* (Codd) Hilliard. In *J. bergae*, however, the flowering branches, although terminal, do not form racemes with leaves degenerating into bracts. The flower colour is a brilliant scarlet, not white or mauve as in *J. grandiflora* and *J. macrantha*, nor varying from green through yellow, orange-brown, maroon to dark brown as in *J. accrescens*. In the most recent comprehensive key to the species of *Jamesbrittenia* (Hilliard 1994), *J. bergae* keys out as *J. accrescens*. The new species is easily distinguished from the latter by its different floral colour, medium-textured corolla limb (the limb is thick-textured in the case of *J. accrescens*), shorter corolla tube (that of *J. accrescens* being 18–25 mm long and thicker), corolla lobes with the apices usually retuse (not ± rounded as in *J. accrescens*) and the margin without a thin-textured, pale, marginal zone (that of *J. accrescens* having a thin, cream to greenish yellow margin). Furthermore, the ovary and capsule of *J. bergae* are glabrous, whereas those of *J. accrescens* are minutely glandular-puberulous. The capsules of *J. bergae* are smaller (4–7 × 2–3 mm) than those of *J. accrescens*, which are 7–10 × 3.5–4.5 mm. *J. bergae*, in addition, has a different habitat and geographical distribution than *J. accrescens*, which is known to grow in rocky places in scrub, often on margins of patches of forest, from the Zoutpansberg eastwards to the eastern highlands of Mpumalanga.

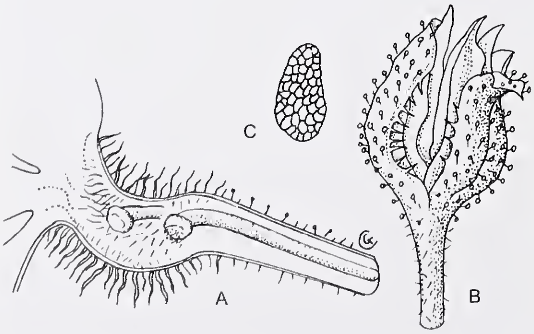

FIGURE 2.—A, l/s corolla tube showing position of stamens, × 3; B, ripe fruit capsule, × 5; C, seed, × 20.

Distribution and ecology: although often locally abundant, *J. bergae* appears to be a rare species, known only from the type locality at present. The plants grow in full sun in crevices on ferricrete outcrops with a southern aspect, in the southern foothills of the 'Berg van Winde' near Thabazimbi, Limpopo [Northern Province] (Figure 1). The altitude varies from 1 056 m to 1 106 m. The area receives an average of 550 mm of summer rain per annum. The vegetation type is Mixed Bushveld (Low & Rebelo 1996).

Herbs and grasses associated with *J. bergae* include *Aristida congesta* subsp. *barbicollis*, *Elionurus muticus*, *Evolvulus alsinoides*, *Merremia tridentata* subsp. *angustifolia* var. *angustifolia* and *Tephrosia longipes* subsp. *longipes* var. *longipes*. Trees and shrubs growing in the vicinity of the new species are *Combretum molle*, *Diplorhynchus condylocarpon*, *Englerophytum magalismontanum*, *Faurea saligna*, *Ozoroa paniculosa* var. *paniculosa*, *Spirostachys africana*, *Strychnos madagascariensis*, and *Ziziphus mucronata* subsp. *mucronata*. The species referred to were recorded in summer after an average rainy season.

Additional material examined

LIMPOPO.—2427 (Thabazimbi): Farm Brakvallei, southern foothills of Berg van Winde, (–CB), *S.E. Strauss 803, 809, 811, 816, 819* (PRE), *S.E. Strauss 812* (E).

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I sincerely thank Dr O.M. Hilliard for her initial guidance and her encouragement, Prof. A.E. van Wyk for his unstinted co-operation and support, Mr P.W. van Schalkwyk for permission to take herbarium specimens, and his hospitality during field work, Mrs S.E. Strauss and Mr A.S. Berga for collecting herbarium specimens, Mr D.A. McCallum of the C.E. Moss Herbarium and Mr T. Trinder-Smith of the Bolus Herbarium for assistance with the genus *Jamesbrittenia*, Dr H.F. Glen for translating the diagnosis into Latin and Ms G. Condy for the painting and text figure.

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FIGURE 3.—*Jamesbrittenia bergae*. Artist: G. Condy. Specimen cultivated from seed collected in the wild.

Bothalia 33,2: 145–147 (2003)

A new *Cyrtanthus* species (Amaryllidaceae: Cyrtantheae) endemic to the Albany Centre, Eastern Cape, South Africa

D.A. SNIJMAN*

Keywords: Amaryllidaceae, Eastern Cape, *Cyrtanthus* L.f., new species, South Africa, transitional vegetation type

ABSTRACT

Cyrtanthus **macmasteri** Snijman is a rare new species from the Albany Centre of endemism, Eastern Cape, South Africa. Most closely related to *C. galpinii* Baker, and autumn-flowering species with a single or rarely-flowered inflorescence from the northern regions of southern Africa, *C.* **macmasteri** is distinguished by a 3 to 6-flowered inflorescence. It grows on steep banks of the Great Kei River and its tributaries and flowers in summer.

INTRODUCTION

Cyrtanthus L.f. is an exclusively sub-Saharan African genus in the family Amaryllidaceae, found only in the southern and eastern parts of the continent and frequently restricted to habitats with distinctive soil types, ecotones or isolated gorges. Dyer (1939) and later Reid & Dyer (1984) reviewed the 50 species known in southern Africa, whereas Nordal (1979) studied the two species and four subspecies from East Africa.

The Eastern Cape is floristically rich, phytogeographically complex and poorly collected (Gibbs Russell & Robinson 1981; Gibbs Russell *et al.* 1984). In 1994 Mr J.C. McMaster, a keen naturalist who repeatedly visited remote localities to record Eastern Cape plants, sent pressed and living plants of this new species collected from near the confluence of the Bolo and Kei Rivers (Figure 1), to the Compton Herbarium. Mrs M.A. Holmes had first recorded matching material (*Holmes NBG70846*) from the same area in 1963. Although previously identified by Miss W.F. Barker as *C. galpinii* Baker, the acquisition of Cameron McMaster's specimens enabled this rarely seen species to be described and illustrated.

Cyrtanthus macmasteri *Snijman*, sp. nov., quoad colorem, magnitudinem et formam florum *C. galpinii* Baker similis, sed floribus multis (3–6) differt. Figura 2.

TYPE.—Eastern Cape, 3227 (Stutterheim): Farm Keibolo, above Bolo River Gorge near its confluence with the Kei River, (–BC), 6 February 1994, *McMaster s.n.* (*NBG192230*, holo.; PRE).

Deciduous, bulbous herb, 200–250 mm tall when flowering. *Bulb* solitary, hypogeal, depressed globose, 25–35 × 30–35 mm diam.; outer tunics papery and brown, extended into a slender neck up to 90 mm long. *Leaves* 1 or 2 each season, most often dying back before flowering and emerging anew after flowering, strap-shaped, 150–320 × 6–7 mm, narrowing up to 2 mm at base and apex, glabrous, somewhat glaucous, reddened at base; adaxial surface channelled; abaxial surface distinctly keeled; margins and midrib minutely papillate towards base. *Inflorescence* 3–6-flowered; scape erect, up to 190 mm long, 4–5 mm diam., tapering distally, glaucous green, flushed with pink near base, solid at base but hollow above; spathe valves 2, equitant, lanceolate, 50–57 × 8–9 mm, herbaceous, reddish turning pale brown, inner withering and reflexing before outer; bracteoles filiform, ± 5 mm long; pedicels erect, ranging from 15–55 × 1.5–2.0 mm in each inflorescence, pale green. *Flowers* secund, spreading horizontally or slightly drooping, opening ± synchronously; perianth funnel-shaped, 37–42 mm long, scarlet, inner surface of tube whitish pink with 6 scarlet streaks leading downwards from tepal sinuses, not scented, producing nectar; tube 25–30 mm long, lower 10 mm narrow, 2–4 mm diam., curved at ± 90°, upper 15–20 mm flaring open to 10–13 mm at throat; tepals ovate, 10–14 × 6–8 mm, outspread at anthesis, outer and inner almost equal, 5–7-veined, firm-textured, without a thickened midrib; apex obtuse, mucronulate; mucro white. *Stamens* biseriate, regular, arising ± three quarters up tube, outer attached 3–4 mm below inner; anthers dorsifixed, oblong, up to 3 mm long, yellow. *Ovary* ellipsoidal, 5–6 × 2–3 mm, green; ovules axile, ± 25 per locule; style pressed against lower tepals, up to ± 9 mm long, exserted beyond stamens, white to scarlet distally; stigma 3-branched, branches slender, truncate, ± 2.0 × 0.5 mm, papillate on inner surface. *Capsule* narrowly

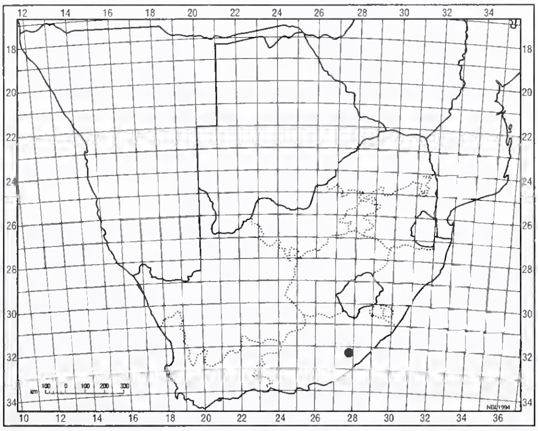

FIGURE 1.—Known distribution of *Cyrtanthus macmasteri* in the Great Kei River Basin, Eastern Cape, South Africa.

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* Compton Herbarium, National Botanical Institute, Private Bag X7, 7735 Claremont, Cape Town.

MS. received: 2003-05-12.

elliptical, ± 30 × 8 mm, 3-valved, valves reflexing when dry. *Seeds* flattened, up to 10 × 4 mm, blackish.

Phenology: the main flowering time is February but sometimes late January and early March if conditions are favourable. Seed ripens at the end of March and by mid-April it has mostly dispersed. The leaves emerge several months prior to flowering and mostly die back before the flowers appear. Under cultivation at Kirstenbosch Botanical Garden, a new leaf is often produced within a month after flowering.

Diagnostic features: it is possible to group the species of *Cyrtanthus* by their flowers. Several species have a perianth in which the tube is narrow at the base and then flares widely to the throat. Reid & Dyer (1984) grouped together 13 species defined by this floral form. Of these, *C. elatus* (Jacq.) Traub, *C. guthrieae* L.Bolus and *C. montanus* R.A.Dyer have regular flowers without markings. The other 10 species have distinctive lines running into the throat from the tepal sinuses, the style and often the stamens flex downwards against the lower tepals, and the stigma has three long branches. These include five red-flowered species allied to *Cyrtanthus sanguineus* (Lindl.) Walp. and three species with lemon to pale pink flowers related to *C. loddigesianus* (Herb.) R.A.Dyer.

Based on its flared tube, paler throat with darker streaking, and deflexed style with a three-branched stigma, *C. macmasteri* falls clearly into the group comprising *C. thorncroftii* C.H.Wright, *C. galpinii*, *C. eucallus* R.A.Dyer, *C. sanguineus*, and *C. flammosus* Snijman & Van Jaarsv. The inclusion here more recently of *C. wellandii* Snijman in which the stamens and style are included low down in the tube is discussed in Snijman & Batten (2003).

Of the smaller-flowered species belonging to the *C. sanguineus* group, *C. macmasteri* is most similar to *C. galpinii,* a species from Zimbabwe, Mozambique, Mpumalanga, Swaziland and northern KwaZulu-Natal. Both have narrow (less than 7 mm wide), hysteranthous leaves that taper to a narrower base (1–2 mm wide), and flowers that flare widely to a pale perianth throat (at least 10 mm across) with contrasting streaks leading down into the tube. In *C. galpinii* the flowers are variable, although mostly red they may also be pink or orange. In southern Africa the perianth is 50–75 mm long, whereas the specimens from Zimbabwe that are usually called *C. galpinii* have shorter perianths, 30–60 mm long (Nordal 1979). In plants from Zimbabwe *C. galpinii* may rarely have two flowers per inflorescence, however, elsewhere the inflorescence is consistently single-flowered and appears from March to July. In *C. macmasteri* the length of the perianth (37–42 mm) overlaps the smaller forms of *C. galpinii,* but the species differs in having a 3–6-flowered inflorescence which is produced mainly in February.

It is possible to confuse poorly prepared specimens of *C. macmasteri* with those of *C. collinus* Ker Gawl., an unrelated species of the Cape Region that extends along the Cape Fold Mountains from the Riviersonderend Range, Western Cape to the Zuurberg, Eastern Cape. This is due to the perianth tube in *C. collinus* sometimes being slightly flared towards the mouth. However, the flowers are uniformly red and without nectar guides, the style and trifid stigma arch against the upper tepals and the leaves are V-shaped in cross section, lacking the distinct keel found in *C. macmasteri.*

Distribution and habitat: *Cyrtanthus macmasteri* is known only along the steep east- and south-facing banks of the Great Kei River and its tributaries, the Bolo and Nqancule Rivers (Figure 1). It grows singly, is never common and is confined to altitudes of 640 to 1 100 m, where Valley Bushveld gives way to Dohne Sourveld (Acocks 1975), mostly amongst sandstone rocks of the Beaufort Group and less frequently in soils weathered from dolerite intrusions, with less than 500 mm annual rainfall. Woody shrubs and small trees scattered throughout the habitat include *Acacia karroo, Carissa bispinosa, Cussonia spicata, Diospyros whyteana, Encephalartos princeps,* and various species of *Rhus*. Other species of *Cyrtanthus*, which are sympatric with C. *macmasteri*, are *C. macowanii* Baker (*McMaster NBG182475)* and *C. obliquus* (L.f.) Aiton (*Snijman 1639*, NBG) but their peak flowering times do not overlap. Following the IUCN Red List criteria the species is categorized here as LR (lc): lower risk and of least concern.

Endemism: many authors (Nordenstam 1969; Cowling & Hilton-Taylor 1997; Van Wyk & Smith 2001) have reported high levels of endemism in Eastern Cape, particularly in the Albany Centre. Following Van Wyk & Smith (2001), *C. macmasteri* is a noteworthy example of an Albany Centre endemic that has affinities with the subtropical eastern regions of sub-Saharan Africa.

ACKNOWLEDGEMENTS

Mr J.C. and Mrs R. McMaster are thanked for their invaluable help with collecting data and specimens of Eastern Cape *Cyrtanthus.* Mr G. Duncan is gratefully acknowledged for data from the bulb collection at Kirstenbosch. Mrs A. Batten generously made available her painting of *C. macmasteri* for publication. The colour illustration was kindly sponsored by Starke-Ayres Nursery.

Other specimens examined

EASTERN CAPE.—3227 (Stutterheim): steep eastern aspect near highest point of Farm The Deeps, (–BC), 5 March 1998; *McMaster s.n.* (PRE), 24 January 2000, *McMaster NBG192237*; Farm Keibolo above Bolo River Gorge near its confluence with the Kei River, (–BC), 29 January 1995, *McMaster s.n* (K); slopes down to Nqancule and Kei Rivers, (–BD), *Holmes NBG70846.*

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FIGURE 2.—*Cyrtanthus macmasteri,* × 1. A, bulb; B, mature leaves; C, inflorescences; D. l/s flower; E, capsule; F, seed. Painted from *McMaster NBG192330* collected at Farm Keibolo (NBG). Artist: Auriol Batten.

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Understanding *Erica ×willmorei*, a nineteenth century English garden hybrid

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Keywords: *Erica* L., garden history, nomenclature

ABSTRACT

The application of the binomial *Erica willmorei* Knowles & Westc. is discussed and the name is typified by an illustration. It is demonstrated that the name was altered to *E. wilmoreana* by Bentham, misapplied and misspelled soon after publication and that various plants known by this binomial and its numerous variants do not represent the original hybrid.

INTRODUCTION

A brief history of hybrid Cape heaths

In Britain during the late eighteenth and early nineteenth centuries there was immense interest, at least among wealthy garden owners, in forming collections of, and in cultivating, species of *Erica* from southern Africa, the so-called Cape heaths. Collectors, especially Francis Masson (1741–1805) (Bradlow 1994) and James Niven (1776–1827) (Nelson & Rourke 1993), were engaged to go to the Cape of Good Hope and to search for new species, to gather seeds and to send these to their sponsors and patrons in Europe. These collectors were remarkably successful, and so were the gardeners and nurserymen who received the wild-collected seeds. Seedlings of many hitherto unknown species were raised and substantial numbers were grown on to flowering stage. These plants provided the subjects for a series of splendid illustrated books, of which probably the most notable was Henry Charles Andrews's *Coloured engraving of heaths*, a part-work issued between 1794 and about 1830 (Cleevely & Oliver 2002).

Cape heaths were among the most fashionable plants of this period. Wealthy enthusiasts indulged their passion for them to the utmost, even building special glasshouses to accommodate and protect the plants, and amassing collections of hundreds of different species and varieties. In such circumstances, the nurserymen, on whom the overwhelming majority of the Cape heath fanciers depended for novelties, had to strive to ensure that new species were continually available. While wild-collected seed was the principal means of achieving this, the cost of obtaining the seeds of more and more new species was undoubtedly enormous in both financial terms and in terms of the seed collectors' time. There came a point when employing a collector and basing him at the Cape of Good Hope became entirely uneconomical.

By the early 1800s it is certain that at least two hundred different Cape heaths were in cultivation in Europe—the list of heathers (including European species) offered in 1802 by Lee and Kennedy of Hammersmith included 228 species and varieties. Less than a decade later Smith (1809) remarked that while it was 'difficult to guess at the number of the real species of *Erica* ... our gardeners reckon about 300, many of which are merely varieties ...'. Even if the plants did not represent that number of distinct species, they still constituted a remarkably diverse assembly of plants, and there can be little doubt that the nurserymen who grew Cape heaths made special efforts to propagate the best ones. Many could be increased only by cuttings, but the fact that the shrubs bloomed did mean that seeds could potentially be harvested without the necessity of sending collectors to the Cape.

Many Cape *Erica* species have exacting pollination requirements—pollinating agents in the wild range from nectar-feeding birds to insects and the wind (Rebelo *et al.* 1985). Specialized animal pollinators are inevitably absent when plants are cultivated in regions far-distant from their natural habitats, and thus, in cultivation, pollination may never be effected and viable seed will not form. On the other hand, considering that in the early nineteenth century in Europe, an individual Cape heath collection could contain more than a hundred species, and that these would have been contained in a single glasshouse, the potential even for accidental cross-fertilization by 'alien' pollinators was enormous. However, the absence of 'natural' pollinators can be overcome by hand-pollination, and it is evident that European gardeners were soon adept at pollinating—and cross-pollinating—the Cape heaths in their care.

No precise record has been traced recording the first instance of garden-harvested seed, nor of the first seedlings from such seed, but there is indirect evidence that around 1790 at least one English nurserymen had succeeded in obtaining and germinating home-produced seed from Cape heaths. Moreover, he had also artificially cross-pollinated two species and produced a hybrid. The nurserymen was William Rollisson (his surname is frequently misspelled Rollinson), and he used two Cape heaths named *Erica grandiflora*† and *E. vestita* as the

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† We have deliberately omitted the authorities for many of the binomials used herein for two reasons: firstly, because it is impossible often to establish the true identity of the plants concerned, and secondly, because some of the names were first published in nurserymen's lists and the correct attribution of the specific or varietal epithets has yet to be established.

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FIGURE 1.—The illustration × 1, by R. Mills, published by Knowles & Westcott (1838), here designated the iconotype of *Erica ×willmorei*. By courtesy of Ian A. Nex, Archivist and Librarian, The Birmingham Botanic Gardens, and reproduced by permission of The Director, The Birmingham Botanic Gardens.

parents of the hybrid which was released under the names *E. vestita* var. *fulgida* or *E. fulgida* (Rollisson 1843). Rollisson kept this a secret, and it is clear from subsequent comments by his contemporaries, for example Henry Andrews, that Rollisson passed off his hybrid plants as new species raised from seeds gathered in the wild at the Cape of Good Hope.

That others also carried out artificial pollination and cross-pollination is highly likely, yet the first explicit reference to it dates from 1817 when the Dean of Manchester, the Rev. William Herbert, who is best known for his work with Amaryllidaceae, casually remarked that he had raised some hybrids of Cape heaths: 'and the new heathers I have already obtained, are most distinct and remarkable, the individuals of each new species [*sic*] being perfectly uniform' (Herbert 1818).

Various comments published by Andrews (1794 to ± 1830) reveal probable hybrids. Of *Erica rupestris* var. *rubra* he wrote: 'This *Erica* was raised from British seed gathered from the *E. rupestris*, in the Autumn of 1807, by Mr. Knight, nurseryman in the King's Road, Chelsea, and is the only one, out of a number sown, that vegetated.' Using the rather obtuse phrase 'seminal variety', Andrews (1794 to ± 1830) signalled some more: *E. coventrya* was 'one of those fine seminal varieties raised from Cape seed at the Hammersmith Nursery'; *E. refulgens* was 'considered as a seminal variety of the *E. versicolor*'; *E. stellifera* 'supposed to have been raised from seed of *E. ventricosa*, or *praegnans* ... is also another seminal variety'.

The original *Erica* ×*willmorei*

Erica willmorei was one of the plants featured in *Floral Cabinet and Magazine of Exotic Botany*, published in Birmingham, a short-lived periodical edited by George Beauchamp Knowles (± 1800–1860), who was Professor of Botany at the Birmingham School of Medicine, and Frederic Westcott (d. 1861). Their aim was admirable, to provide 'accurate, and at the same time, *highly finished* representations of such plants as are remarkable for their beauty, their rarity, or their peculiarity of structure' (see Desmond 1977). The periodical lasted just three years, and among the plant portraits was one of a new hybrid heather which Knowles & Westcott (1838) named '*Erica willmorei*, Mr Willmore's Erica': 'This hybrid variety of *Erica* is in the collection of John Willmore, Esq. of Oldford, and was raised by that gentleman's gardener, Mr. John Williams, whose skill and perseverance have been that means of introducing an immense number of beautiful hybrids, particularly *Calceolarias*, many of which are infinitely more beautiful than any of the original species'.

The coloured plate (Figure 1) was accompanied by a Latin description and an English translation, so the binomial *E.* ×*willmorei* Knowles & Westc. is validly published, and while no contemporary herbarium specimens matching the descriptions and illustration have yet been traced, the name can be typified by the published plate.

E. ×willmorei *Knowles & Westc.*, Floral Cabinet and Magazine of Exotic Botany 2: 115, t. 73 (1838). Iconotype: Floral Cabinet and Magazine of Exotic Botany 2: t. 73 (1838) selected here.

E. ×*wilmoreana* [*sic*] Benth. in DC.: 661 (1839).

'Leaves in threes, linear, channelled, bracteas close to the calyx; sepals ovate-lanceolate, acute; flowers axillary; corolla tubular-ventricose, semi-pellucid; anthers included; stigma somewhat exserted. Flowers rather transparent, in shape somewhat intermediate between tubular and ventricose, of a bright but rather pale red, the mouth 4-parted, divisions rounded, of a beautiful green with a distinct white margin.' Figures 1; 4A.

Knowles & Westcott (1838) did not provide any information about the parentage of *E.* ×*willmorei*, except to comment that it was 'interesting as affording a proof of the possibility of obtaining hybrid varieties between Heaths with tubular flowers, and those with globose flowers; or, to use the language of gardeners, between the pill and the tube, a fact which we believe has been very generally denied'.

We suggest that *E.* ×*willmorei* was a hybrid derived perhaps from *E. blenna* Salisb., a Cape heath that was certainly in cultivation during the early nineteenth century principally under the synonym *E. vernix* Andrews, and another undetermined species with a long, tubular corolla. John Willmore, after whom this hybrid was named, lived at Oldford, a suburb of Birmingham where he had a fine garden with a 'rich collection' of exotic plants.

Erica wilmoreana and other orthographic variants

It is necessary at this point to note that Bentham (1839), citing Knowles & Westcott (1838) as the authority, altered the name to *E. wilmoreana*, not only misspelling it—a difficulty that recurs far too frequently when this name is employed—but also, unnecessarily, amending the termination. Thus *E. wilmoreana* (and all variant spelling of it) is a synonym of *E.* ×*willmorei* (and all its variants) and is not available for use for any plant other than the one illustrated by Knowles & Westcott (1838). Concerning these orthographic variants, it is apposite to note Dauthenay's (1900) remarks on the name: 'Nous avons désigné l'espèce de Bruyère qui fair le sujet de cet article sous le nom d'*Erica Wilmorei*. On l'appelle aussi *E. Wilmoreana*, mais quelques personnes, évidemment mal renseignées, en ont fait l'*Erica Vilmoriniana*. Ces deux mots ont évidemment une certaine ressemblance dans leur consonnance. Pour éviter cette confusion, il suffirait, dans ce cas particulier, de respecter la loi de priorité'.

The orthographic variants and typographic errors, recorded (to September 2002) in The Heather Society's database of heather names for *E.* ×*willmorei*, are as follows (only the earliest records are noted, arranged alphabetically):

E. villmoreana: *Garten Magazin* 51: 203 (1898).

E. villmoriniana: *Flora capensis* 4,1: 315 (1905).

E. vilmoreana: *Journal of the Linnean Society* 24: 180 (1887).

FIGURE 2.—This specimen from Joseph Dickinson's herbarium (LIV) is labelled '*Erica willmorei* hybrid 1837'. It is not the same plant as that illustrated by Knowles & Westcott (1838). It is exactly 104 mm long from base to tip. By courtesy Dr L. Wolstenholme, and reproduced by permission of The Board and Trustee of the National Museums & Galleries on Merseyside, Liverpool.

E. vilmoriniana: *Revue Horticole* 1891: 235 (1891).

E. wilmoreana: DC., *Prodromus* 7: 661 (1839).

E. willmoreana: *The Gardeners' Chronicle* 22 October: 711 (1842).

E. willmoriana: *Revue Horticole* 1891: 235 (1891).

E. wilmorea: *Deutsches Magazin für Garten* 36: 69 (1883).

E. wilmorei: Catalogue, James Veitch & Sons, 70 (1873, 1874).

E. wilmoreii: *Erica* stock list, Ericaflora, Monbulk, Victoria, Australia, not dated [± 2000].

E. wilmoriana: *The Gardeners' Chronicle* 27 August: 569 (1842).

Other *Erica* "*willmorei*" and *Erica* "*wilmoreana*"

To complicate matters, the first author recently became aware of the existence in the herbarium of Liverpool Museum (LIV) of a specimen labelled, in the handwriting of Joseph Dickinson, 'Erica Willmorei Hybrid 1837' (Figure 2). This particular specimen was most probably taken from a plant growing in Liverpool Botanic Garden—Dickinson was Secretary of the Liverpool Botanic Garden Trust, and the specimen derives from his herbarium of cultivated plants (J. Edmondson pers. comm. 2002). Beyond doubt, the specimen does *not* represent the plant illustrated by Knowles & Westcott (which will be referred to henceforth as *K&W73* [i.e. Knowles & Westcott, *Floral Cabinet and Magazine of Exotic Botany* 2: 115, t. 73 (1838)].

The Dickinson specimen represents an *Erica* with hirsute flower buds (not glabrous as in *K&W73*), ± 15 mm long, club-shaped with distinctly swollen tips (not elongate-ovoid, swollen towards the base, as in *K&W73*). The leaves, ± 5 mm long, are ciliate (not glabrous as in *K&W73*). The specimen has not been examined, but a xerox print, enlarged twice, on which these details can be very clearly seen, was studied by us.

The first and obvious conclusion is that by 1837 Wilson, John Willmore's gardener, had succeeded in producing no fewer than two hybrids, probably of entirely different parentage, and that these had been distributed to other gardeners either under the name *Erica* "*willmorei*" or, more probably, without a name in which case the recipients subsequently labelled these for their own convenience as *Erica* "*willmorei*" (this is not an uncommon occurrence, even today, in gardens and nurseries).

While Knowles & Westcott (1838) chose, for whatever reason, to illustrate a seedling with elongate-ovoid flowers and glabrous foliage, which perhaps soon became extinct in cultivation, it seems that the plant represented by the specimen in Joseph Dickinson's herbarium was a seedling (probably from a group of seedlings) that was destined to continue to flourish in various gardens. That it was successfully propagated and distributed cannot be doubted—there are several different pieces of evidence indicating this.

In 1842 there was sufficient doubt about the exact identity of at least one plant labelled *Erica* "*willmorei*"/"*willmoreana*" for Regel (1842) to list '*Erica wilmoreana* hortulanis Dresden' and comment as follows: 'E. Wilmoreana der Dresdener Garten ist eine selbst als Bastard nur schwierig von E. Linnaeoides zu unterscheidende Pflanze und einzig durch noch buschigeren Wuchs und in der Witte etwas angeschwollene Blumenrohre verschieden.'

Dickinson's specimen exhibits superficial resemblance to an illustration (Figure 3) labelled 'Wilmore's heath (*Erica wilmoreana*)' published by Step (1897). The flower buds in the illustration are similar in shape to those of Dickinson's specimen, and while they are not depicted as being hirsute, there is again ample evidence that plants labelled *Erica* "*wilmoreana*" were rather variable (see Figure 4).

The earliest description that has been traced of *Erica* "*wilmoreana*" which is not directly derived from Knowles & Westcott (1838) was published by Paquet (1844): 'Belle plante d'un aspect blanchâtre, à feuilles velues, quaternées; fleurs en tube, bilabiées, roses à la partie inférieure, blanches au sommet.' This albeit brief characterization matches later descriptions and also Step's illustration (1897) (Figure 3), although the leaves depicted therein are not hairy ('à feuilles velues') as described by Paquet (1844). However, Nicholson (1885) noted that the linear leaves of *Erica* "*wilmoreana*" were 'covered in short white hairs, as also are the branches.' Carrière (1892), describing *Erica* "*wilmoreana*" and three of its cultivars, noted that in *Erica* "*wilmoreana glauca*": 'La villosité sur la corolle est beaucoup plus pronouncée sur cette plante que sur toutes les autres de ce même groupe, chez la plupart desquelles la corolle est glabre, tandis que chez cette variété *glauca* la corolle est parfois presque hispide, ce qui suffirait pour la différencier.' Otherwise, most de-

FIGURE 3.—'Wilmore's heath (*Erica wilmoreana*)' from Step (1897: t. 164). Main shoot, × 0.68. Note the shape of the flowers, with the swollen tips, and compare with those on the specimen in Figure 2. Reproduced by courtesy of the Lindley Library, Royal Horticultural Society, London.

scriptions of this heath are perfunctory, concentrating on flower colour.

Erica "*wilmoreana*" was listed in English nurserymen's catalogues in the 1870s and 1880s—for example, James Veitch & Sons (1873–1874); William Rollisson & Sons (1877); B.S. Williams (1881)—but what Cape heath they were actually growing and selling is impossible to determine. Illustrations of so-called *Erica* "*willmorei*" appeared in *The Garden* (1889) (see Figure 5), *Revue Horticole* (1892, 1900) and, as already noted, in Step's *Favourite flowers for gardens and greenhouse* (189: 3: t. 164) (see Figure 3). In *The Gardeners' Chronicle* on 15 February 1896, Hudson (1896) described and illustrated *Erica* "*wilmoreana*": 'The present is a most fitting season for drawing attention to one of the finest of all the early spring-flowering Heaths. It is one of the earliest hybrids raised in this country, being brought into notice about sixty years ago. Of its parentage I have no record, but as regards the value of the offspring there can be no question, whether for the greenhouse or conservatory. Under good cultivation it is a long-lived variety, being a most vigorous grower ... The colour of the flowers is deep pink, tipped white, and they last in good condition several weeks.' The accompanying illustration (Figure 5) showed a floriferous plant, nothing whatever like that illustrated by Knowles & Westcott (1838) [the right-hand specimen was shown in the plate published seven years earlier in *The Garden* (1889)].

CONCLUSION

This paper touches on an almost intractable subject, the correct application of the numerous binomials given to cultivated plants of Cape heaths by European, but especially English, nurserymen, gardeners and horticultural authors during the first half of the nineteenth century when erica-mania was in its most efflorescent phase. These names are recorded in a database compiled by The Heather Society, acting as ICRA (International Cultivar Registration Authority) for *Erica*, which will form the source for the second volume of the *International register of heather names* [the first volume (Nelson & Small 2000) listed only the names of hardy cultivars and European species]. In many, if not most cases, the names must remain designated as *incertae sedis*.

The International Code of Botanical Nomenclature establishes rules for the naming of plants including primary hybrids of garden origin. Even though its parentage may not be recorded, the application of any hybrid binomial is precisely determined by reference to protologue

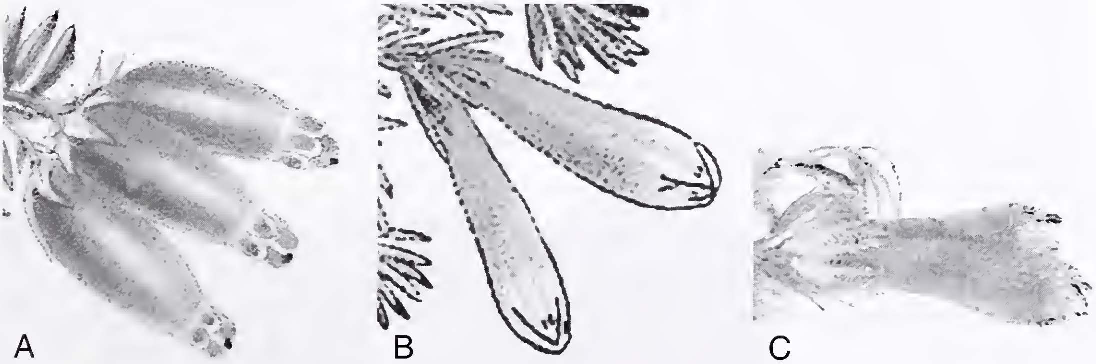

FIGURE 4.—Details from the illustrations: A, published by Knowles & Westcott (1838: see Figure 1), × 2.2; B, Step (1897: see Figure 3), × 2.7; and C, of the specimen in LIV (Figure 2), × 2.7. The flowers in A are red with green lobes prominently margined with white; note the emergent anthers. The flowers of B are red with white lobes; the anthers are included.

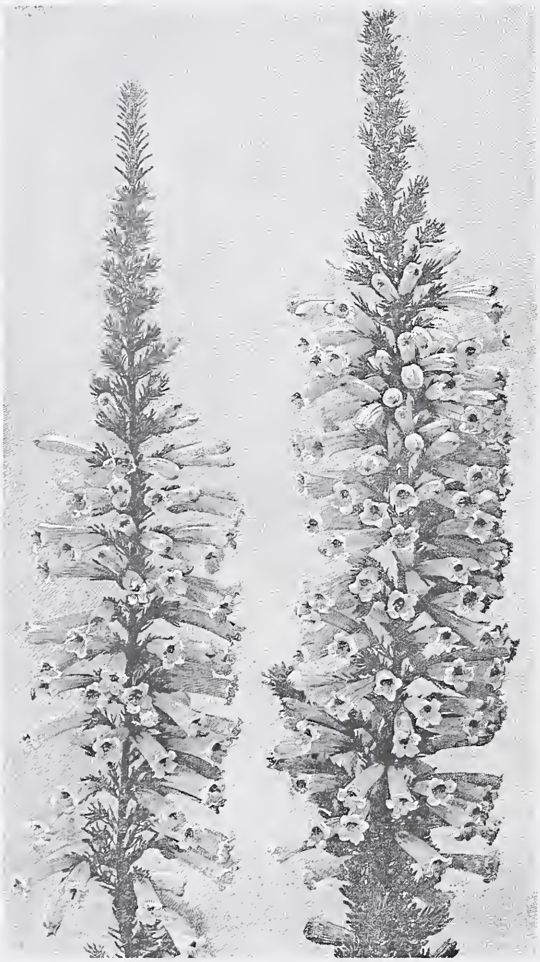

FIGURE 5.—'*Erica willmoreana* ×'. One of several illustrations evidently derived from a photograph; first published in *The Garden* on 2 February 1889 (only the right-hand shoot was shown), this version appeared in *The Gardeners' Chronicle* on 15 February 1896, × 0.56.

(the original published description) and the associated materials which may include herbarium specimens and illustrations. In this case no herbarium material has been traced but an excellent illustration which accompanied the protologue, and now designated as the iconotype, serves to establish the exact application of the binomial *Erica* ×*willmorei.* The fact that an herbarium specimen bearing the name 'Erica Willmorei' and dated 1837 is extant is not relevant, because it indubitably is an entirely different plant and is not connected in any way to the protologue. It is clear that this binomial was misapplied soon after its publication in 1838, and it was also subject to misspelling.

It remains to be established what the correct identities, and thus the correct names, are of cultivated and naturalized plants presently called *Erica willmorei* (or *E. willmoreana*, etc.). These include several cultivars, as well as plants reported as naturalized in several parts of Australia. Until specimens can be obtained and studied, the identity of these plants cannot be resolved.

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Notes on African plants

VARIOUS AUTHORS

EUPHORBIACEAE

EXCOECARIA MADAGASCARIENSIS; A FIRST RECORD FOR THE *FLORA OF SOUTHERN AFRICA* REGION

While collecting specimens for the compilation of the *Tree atlas of Swaziland*, an unknown plant was collected by P. Loffler & L. Loffler in the Lubombo Mts near the Mozambique border. A literature search led to the specimen's tentative identity as *Excoecaria madagascariensis* (Baill.) Müll.Arg (1866). Since the Swaziland locality was so far distant from its nearest locality in Chirinda Forest, Zimbabwe, the site was re-visited in November 2002. Despite intensive searching of the area, only a single specimen of *Excoecaria* was found, although not the same as the original plant, which was not re-located. However, it's identity was undisputed, the new glossy red leaves which gives it the Zimbabwean common name of 'red-ears' being conspicuous. The plant was in both flower and fruit (Figure 1A, B).

Described from Madagascar, *E. madagascariensis* also occurs in Somalia (Thulin 1993), the coastal forests of Kenya and isolated inland forests in Tanzania (Radcliffe-Smith 1987). A disjunct locality is represented by its occurrence as a fairly common understorey species in Chirinda Forest in southeastern Zimbabwe. The new locality extends its distribution by almost 700 km and represents a further considerable disjunction for the species, as well as a new record for the *Flora of southern Africa* region.

The habitat in which the *Excoecaria* occurs in the Lubombo Mountains, is in dry, evergreen forest situated on the floor of a valley near the Mtibhlati River at an altitude of 240 m a.s.l. The canopy is dominated by *Atalaya alata* (Sapindaceae), *Balanites maughamii* (Balanitaceae), *Chionanthus foveolatus* subsp. *foveolatus* (Oleaceae), *Ficus polita*, *F. petersii* (Moraceae), *Homalium dentatum* (Flacourtiaceae), *Margaritaria discoidea* subsp. *fagifolia*, *Spirostachys africana* (Euphorbiaceae), *Strychnos usambarensis*, *S. gerrardii* (Strychnaceae) and *Wrightia natalensis* (Apocynaceae). Understorey small trees and shrubs include *Diospyros natalensis* subsp. *nummularia* (Ebenaceae), *Erythroxylum emarginatum* (Erythroxylaceae), *Hyperacanthus amoenus* (Rubiaceae), *Salacia leptoclada* (Celastraceae), *Teclea gerrardii* (Rutaceae), *Tinnea barbata* (Lamiaceae) and *Uvaria lucida* (Annonaceae). A herb layer is almost absent.

The immediate area in which the *E. madagascariensis* grows is severely threatened by the uncontrolled spread of alien invader plants, particularly *Melia azederach* and *Chromolaena odorata*, both of which form pure stands along the nearby flood-damaged river. Despite being in relatively undisturbed climax forest, the entire area around the single *Excoecaria* plant was dotted with small *Melia* seedlings. Further down the river the riverine vegetation and adjacent forest is being cleared for cultivation, a process which may well reach the *Excoecaria* site. In addition, certain trees (notably *Wrightia natalensis*) are being felled either for medicinal plant material or construction purposes. In view of the apparent extreme rarity of this plant, *Excoecaria madagascariensis* must be regarded as critically threatened in Swaziland.

Excoecaria madagascariensis *(Baill.) Müll.Arg.* in DC., Prodromus systematis naturalis regni vegetabilis 15,2: 1219 (1866); Radcl.-Sm.: 383, t. 72 (1987); Thulin: 306, t. 176 E–G (1993); Radcl.-Sm.: 316 (1996); M. Coates Palgrave: 518 (2002). *Stillingia madagascariensis* Baill.: 522 (1858). *Spirostachys madagascariensis* Baill.: t. 8/19, 21 (1858). *Sapium madagascariensis* (Baill.) Prain: 1010 (1913), non Pax (1890); Brenan: 226 (1949). Type: Madagascar, Nosy Bé (Nossi Be), *Pervillé 475* (P, holo., G, K).

Excoecaria sylvestris S.Moore in Rendle et al.: 204 (1911). Syntypes: Zimbabwe, Chipinge Dist., Chirinda Forest, 31 Jan. 1906, *Swynnerton 72* (BM, K, SRGH) & Oct 1908, *Swynnerton 72a* (BM).

SWAZILAND.—2632 (Bela Vista) Lubombo Mts, Siteki Dist., Mtibhlati/Mtibalati River, 26°33'13"S, 32°06'22"E, 240 m, 22 Nov. 2002, *Burrows & Loffler 7893* (Buffelskloof Herb., PRE, SDNH).

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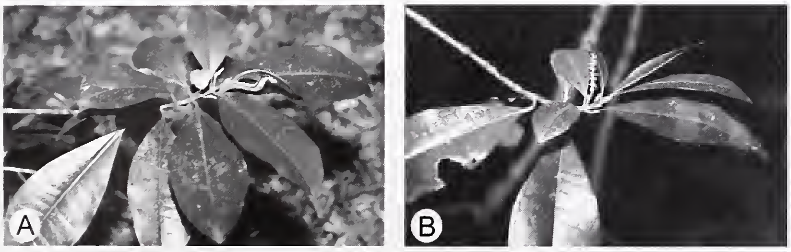

FIGURE 1.—*Excoecaria madagascariensis, Burrows & Loffler 7893*: A, fruiting branch; B, inflorescence.

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LYCOPERDACEAE—GASTEROMYCETES

CALVATIA SECT. *MACROCALVATIA* REDEFINED AND A NEW COMBINATION IN THE GENUS *CALVATIA*

INTRODUCTION

Whilst accepting Kreisel's (1992) incorporation of the genus *Langermannia* Rostk. into *Calvatia* Fr., we, like others (e.g. Calonge & Martin 1990; Demoulin 1993; Lange 1993; Calonge 1998), are not convinced of the generic status of his segregate genus *Handkea* (Kreisel 1989). Kreisel (1989) referred to *Handkea* those members previously placed in *Calvatia*, but characterized by 'aseptate, slit-like, pitted capillitium', and included species with sterile bases (compact or cellular) and without.

For the same reasons as expressed in Lange (1993), and from conclusions based on our own comparative morphological and anatomical studies of the Lycoperdaceae of southern Africa (to be reported elsewhere), we agree with Lange (1993) in treating *Handkea* as a section of *Calvatia*. To that purpose Lange (1993) relegated the genus *Handkea* Kreisel to sectional rank under the name *Calvatia* sect. *Handkea* (Kreisel) M.Lange. Lange's sectional name was not validly published, however, since the requirements of ICBN Art. 33.3 (Greuter *et al*. 2000) were not met. Moreover, Lange apparently overlooked the fact that, long before the establishment of the genus *Handkea*, Kreisel (1962) had established *Calvatia* sect. *Macrocalvatia* Kreisel, to which he assigned *Calvatia excipuliformis* (Scop.: Pers.) Perdeck [= *Handkea excipuliformis* (Scop.: Pers.) Kreisel] and *Calvatia utriformis* (Bull.: Pers.) Jaap [= *Handkea utriformis* (Bull.: Pers.) Kreisel], the latter being the type species of the genus *Handkea*. *Calvatia* sect. *Macrocalvatia* is thus also pertinently cited as an earlier synonym of *Handkea* by Kreisel (1989). Therefore, if the latter two species, (and a number of other species of *Handkea*) are to be accommodated in *Calvatia*, there already exists a section for them, namely *Calvatia* sect. *Macrocalvatia*.

A problem arises, however. The original diagnosis for *Calvatia* sect. *Macrocalvatia*, as defined by Kreisel (1962: 163), is unambiguous: '*Subgleba distincte cellosa. Capillitium non septatum.*' This diagnosis clearly provides for species with fruit bodies characterized by cellular sterile bases only and excludes those with compact bases as well as those without sterile bases. *Calvatia* sect. *Macrocalvatia* in the sense of Kreisel can therefore neither accommodate all of the species assigned to *Handkea* by Kreisel (1989) nor all of those assigned to *Calvatia* sect. *Handkea* by Lange (1993). Instead of establishing yet another new section to accommodate the excluded species, however, we here emend the circumscription of *Calvatia* sect. *Macrocalvatia* to accommodate also those *Handkea* species currently excluded by the original diagnosis.

Emended sectional description

Calvatia sect. **Macrocalvatia** *Kreisel* in Feddes Repertorium 64: 163 (1962), emend. *J.C.Coetzee, Eicker & A.E.van Wyk*. Type species: *Calvatia excipuliformis* (Scop.: Pers.) Perdeck.

Handkea Kreisel: 282 (1989); *Calvatia* sect. *Handkea* (Kreisel) M.Lange: 143 (1993), nom. inval.

Fruit bodies with sterile base or not. *Capillitial septa* extremely rare to essentially absent, easily missed; capillitial threads fragmenting at septa or more commonly by irregular rupturing of walls; capillitial walls fragile, with small perforations and conspicuous slit-like fissures, often between perforations.

New combination in Calvatia

The inclusion of *Handkea* into *Calvatia* necessitates the following new combination (description based on dry herbarium material; colour codes and colour terms follow Kornerup & Wanscher 1981):

Calvatia capensis *(Lloyd) J.C.Coetzee, Eicker & A.E.van Wyk*, comb. nov. Type: South Africa, Stellenbosch, *A.V. Duthie 403* (Lloyd Myc. Coll. 7567 in BPI 706162, holo.!; Herb. v.d. Byl in PREM 31472, iso.!).

Lanopila capensis Lloyd in Mycological Writings 7: 1177 (1923); Verwoerd: 25 (1925); Bottomley: 579 (1948).

Handkea capensis (Lloyd) Kreisel & G.Moreno: 84 (1996).

Illustrations: Lloyd: t. 230, fig. 2352 (1923); Kreisel & G.Moreno: 86, figs 1–7 (1996).

Basidiocarp epigeous, with prominent rooting base, ± globose (sensu Verwoerd 1925; Bottomley 1948), holotype appearing to have been ± 30 mm wide and 25–30 mm high, dehiscing by irregular fragmentation of peridium. *Peridium* very thin, 0.09–0.2 mm, rigid but brittle and extremely fragile, differentiated into an exo- and endoperidium (two layers not discernible from type material, however). *Exoperidium* dark brown with reddish tinge (7F6) to paler and concolorous with endoperidium, fugacious, remaining as tiny, weft-like mycelial patches on some specimens. *Endoperidium* consisting of a thin, amorphous crust overlaying a slightly thicker hyphal layer, surface colour various shades of pale to darker brown [± 5C5 (topaz) and 5D5 (clay) to 6E6 (cocoa brown/leather brown/tan) to almost 7D5], with an evanescent metallic gloss, disappearing with time (persistent only in folds on holotype), leaving surface dull brown, colour of inside surface ± 5D6 (honey yellow/oak brown) to 5E6 (mustard brown), outer surface of holotype ornamented with numerous, tiny, off-white, stellate ridges. Hyphal layer of endoperidium composed of cyanophilic, branched hyphae mostly up to 5 µm diam., but inflated in places, especially at branches and apices, moderately thick-walled (mostly 0.75–1 µm), not tapering but ending in rounded to often inflated tips, true septa infrequent but not uncommon, often perforated with slit-like pits but much less conspicuously so compared to capillitium. *Gleba* cottony to powdery, very fragile, brown (5D5 to 6E6) consisting of spores and capillitium. *Capillitium* golden brown in clear lactophenol, strongly cyanophilic in lactophenol with aniline blue, inamyloid in Melzer's solution, dichotomously branched, commonly up to 7 (rarely up to 11) µm diam., gradually tapering to thin-walled, rounded tips, as little as 1 µm diam., often undulating towards apices, very fragile, breaking up into fragments of varying length, septa not observed; capillitial wall smooth, moderately thickened, mostly varying between 0.5 and 1.25 µm, L/H averaging 0.69 (n = 18) for hyphae 5–7 µm diam., with numerous, very conspicuous, small to large fissures or slit-like pits. *Paracapillitium* absent. *Basidiospores* golden brown in clear lactophenol, cyanophilic reaction variable, inamyloid in Melzer's solution, globose, with short hyaline apiculus mostly less than 1 µm long, but up to ± 1.3 µm not uncommon, uniguttulate, radial symmetric, isopolar, 3–5 µm diam., generally appearing to have a diameter slightly less than much of capillitium; spore wall ± 0.5 µm thick, glabrous under light microscope but distinctly verruculose under SEM, verrucae not more than 0.2 µm high. *Subgleba* present, small (up to 10 mm high), yellowish brown in holotype (5D5) to brown in isotype (6E6), compact, composed of yellow-brown, cyanophilic, branched, much contorted and bent hyphae, commonly up to 7.5 µm diam., tapering like capillitial hyphae, moderately thick-walled (mostly between 1.0–1.5 µm), apparently aseptate, false septa observed but rare; diaphragm absent, boundary with gleba poorly defined.

Distribution: Western Cape, South Africa.

Habitat: soil in a temperate climatic zone with mild, wet winters and hot, dry summers (Mediterranean climate). Fynbos Biome.

Discussion: the material from which Lloyd (1923) first described this fungus consists of one half of a longitudinally bisected specimen sent to him by Miss A.V. Duthie from Stellenbosch, South Africa. In his original description Lloyd made no mention of the subgleba, a feature first described from the other half (the isotype) by Verwoerd (1925). In a footnote to his often overlooked work (in Afrikaans) on South African Gasteromycetes, Verwoerd (1925) had the following to say regarding this puffball (our translation): 'According to Lloyd ... it does not have a sterile base. The half in my possession, however, clearly shows one. Lloyd described it from the other half.' The half described by Lloyd does have a sterile base, however, and it is difficult to understand how he could have overlooked this structure. Contrary to the statement by Kreisel & Moreno (1996), Bottomley (1948) also acknowledged the presence of a sterile base. The holotype is in a very poor state, consisting only of the sterile base with very little gleba still attached to it; the peridium has disintegrated almost completely into tiny fragments.

Although Verwoerd (1925) did not recognize the numerous, very conspicuous slit-like perforations in the capillitial walls of *Lanopila capensis* for what they really were, he did notice the resultant appearance of the capillitium, which he described as '... with a marbled surface', emphasizing the diagnostic value of this character. Bottomley (1948) described the capillitium as having 'a watered appearance'.

Numerous long, thin, angular, needle-shaped crystals, not visible with the naked eye but very conspicuous under the SEM, occur on the peridial surface of the holotype. These crystals were not observed on the isotype, however, and are assumed to be an artefact of unknown origin.

Although Ponce de Léon (1981) excluded this fungus from *Lanopila* Fr., he did not designate it to another genus. On a slip dated 1991, inserted with the type specimen, he assigned it to *Calvatia* Fr., however, albeit with a question mark. Calonge, also on a herbarium slip dated 1992, placed it in *Langermannia*. Based on Bottomley's description of the gleba being 'septate but fragmenting at the septa', Kreisel (1992, 1994) reduced *Lanopila capensis* to synonymy under *Calvatia flava* (Massee) Kreisel. After having examined the holotype, however, he recognized it as a distinct species and placed it in the genus *Handkea* Kreisel on the basis of its slit-like capillitial perforations (Kreisel & Moreno 1996). We prefer to retain it in *Calvatia*, however, assigning it to sect. *Macrocalvatia* emend.

Prior to this study *Calvatia capensis* was known from the type collection only, but a re-examination of the puffballs in the E.L. Stephens collection, recently transferred from BOL to PREM, as well as some specimens from the Lloyd collection in BPI, brought to light at least five more collections of this fungus.

Specimens examined

WESTERN CAPE.—3318 (Cape Town): Rietvlei, 10 June 1951, (–CD or DC), *herb. Stephens 925* (PREM); Rietvlei, (–CD or DC), *herb. Stephens 1931* (PREM); Devil's Peak near wattles, 7 July 1962, (–CD), *Chapman s.n. sub herb. Stephens 4301* (PREM); Stellenbosch, Papegaaiberg, 19 June 1921, (–DD), *A.V. Duthie 304 sub herb. Lloyd 7567* (*BPI706162*, holo., *PREM31472*, iso.). 3418 (Simonstown): Smitswinkel Bay, by roadside, 28 April 1937, (–AD), *R.S. Adamson s.n. sub* *herb. Stephens 452* (PREM). Locality unknown: South Africa, *A.V. Duthie s.n. sub herb. Lloyd 51765* (*BPI709920*).

The following specimens, all with slit-like capillitial pores and semblances of sterile bases are very similar to *C. capensis*, but the material is too scanty to allow for definite identification:

WESTERN CAPE—3318 (Cape Town): Glen, in grass, 12 May 1954, (–CD), *Chapman 424 sub herb. Stephens 1387* (PREM); between Klipheuwel and Bellville, 17 July 1955, (–DA to DC), *herb. Stephens 1500* (PREM). Locality unknown: *herb. Stephens 2032* (PREM).

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ASTERACEAE

A NEW COMBINATION IN THE GENUS *MACLEDIUM* (MUTISEAE)

Klatt (1866) described a new variety of *Dicoma zeyheri*, var. *thyrsiflora*, for a taxon collected in Barberton (Figure 2). Thellung (1921) subsequently raised this variety to the species level, *Dicoma thyrsiflora*. In the same year Moore (1921) described the same taxon as *Dicoma kirkii* var. *microcephala*. Pope (1991) considered this taxon to be an example of variation in *Dicoma zeyheri* subsp. *zeyheri*. While revising the genus *Dicoma*, the first author studied the variation in *Dicoma zeyheri*, and var. *thyrsiflora* was found to be distinct and morphologically different from the typical subspecies. Ortiz (2001) reinstated the genus *Macledium* Cass. and *Dicoma zeyheri* was transferred to this genus. He, like Pope (1991), also recognized only two subspecies: *M. zeyheri* subsp. *argyrophyllum* and *M. zeyheri* subsp. *zeyheri* and included the above discussed taxon under the typical subspecies. It is here proposed that the name of this taxon be reinstated with the correct nomenclatural combination as follows:

Macledium zeyheri *(Sond.) S.Ortiz* subsp. **thyrsiflorum** *(Klatt) N.C.Netnou*, comb. nov.

Dicoma zeyheri Sond. var. *thyrsiflora* Klatt in Bulletin de l'Herbier Boissier 4: 844 (1866). *Dicoma thyrsiflora* (Klatt) Thell. in Thell. & Schinz: 25 (1921). Type: South Africa, Transvaal [Mpumalanga], Kaapriver Valley, Barberton, *Galpin 911* (PRE!, holo.; K, BOL!, iso.).

Dicoma kirkii Harv. var. *microcephala* S.Moore: 231 (1921). Type: South Africa, Transvaal [Mpumalanga], Barberton, *Thorncroft 1074* (BM, holo.; PRE!, iso.).

According to K. Balkwill (pers. comm.), *Macledium zeyheri* subsp. *thyrsiflorum* is a serpentine endemic.

The subspecies of *Macledium zeyheri* are keyed out as follows:

1a Involucral bracts extending 60–280 mm down the capitulum stalk; leaves located basally or absent . . . . *M. zeyheri* subsp. *argyrophyllum*

1b Involucral bracts confined to the head or extending less than 60 mm down the capitulum stalk; plants leafy:

  2a Heads very large, more than 30 mm wide, solitary or up to three on a peduncle; involucral bracts silvery tinged purple, with narrow whitish margins; leaves up to 35 mm wide . . . . *M. zeyheri* subsp. *zeyheri*

  2b Heads relatively small, less than 20 mm wide, often numerous in a panicle; involucral bracts light green with broad, whitish margins; leaves relatively narrow, up to 20 mm wide . . . . *M. zeyheri* subsp. *thyrsiflorum*

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FIGURE 2.—Isotype of *Macledium zeyheri* subsp. *thyrsiflorum*, *Galpin 911* (BOL).

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LYCOPERDACEAE—GASTEROMYCETES

AUTHOR CITATION AND PUBLICATION DATE OF THE NAME *CALVATIA CRANIIFORMIS*

In the course of our taxonomic studies on the genus *Calvatia* Fr. emend. Morgan in southern Africa, we occasionally come across interesting nomenclatural inconsistencies. An important and noteworthy case addressed in this contribution concerns the origin of the name *Calvatia craniiformis*, the type of the genus *Calvatia* Fr., a conserved generic name. Originally described as *Bovista craniformis* by Von Schweinitz (1832), this taxon has subsequently been treated as a member of *Calvatia*.

Throughout the literature, Fries (1849: 442), where the genus *Calvatia* was first established, is consistently cited also as the place of valid publication of the combination *Calvatia craniiformis*. In terms of ICBN Article 33.1 (Greuter *et al.* 2000: 56), however, that is incorrect, since, when Fries (1849) established the genus *Calvatia*, he merely remarked: '*Hujus loci* Bovista cranif. *Schw.*', and nowhere in the original publication did he actually definitely associate the specific epithet *craniiformis* with the genus name *Calvatia* or its abbreviation as required by Art. 33.1. Two similar cases are discussed in Art. 33.1, Ex. 2, which make it very clear that the name *Calvatia craniiformis* was not validly published in Fries (1849).

As far as we could ascertain, the combination *Calvatia craniiformis* was first validly published by De Toni (1888: 106) in Saccardo's *Sylloge fungorum* 7. Although De Toni also ascribed this name to Fries (1849), it should be cited either as *Calvatia craniiformis* (Schwein.) Fr. ex De Toni or merely as *Calvatia craniiformis* (Schwein.) De Toni, and not as *Calvatia craniiformis* (Schwein.) Fr. as has been the exclusive practice in the past.

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MESEMBRYANTHEMACEAE

BRIANHUNTLEYA, A NEW GENUS ENDEMIC TO THE WORCESTER-ROBERTSON KAROO, SOUTH AFRICA

INTRODUCTION

A fundamental principle emerging from Aristotle's biological work, in about 335 BC, and upon which the earliest classification systems were built, is translated as 'the *species* is defined by the *genus* and the *difference*' (Greuter 2002). This Aristotelian logic is at the core of the Linnaean classification system and can be applied to any hierarchical system. The concept becomes more challenging in the case of genera containing single species, and, unlike early classification systems, most modern ones do contain high numbers of monotypic genera (Williams 1964). This has also been shown for Mesembryanthemaceae (Chesselet *et al.* 1995), and currently, 27 genera out of 124, including the one described here, are monotypic. It is one thing to lament monotypes, quite another to find a logical alternate home for, e.g., *Didymaotus* N.E.Br. When a species is sufficiently different from all others, it is necessary to create a new genus to accommodate the 'difference'.

A new monotypic genus, *Brianhuntleya* Chesselet, S.A.Hammer & I.Oliver is here described. It comprises a single species, *Brianhuntleya intrusa* (Kensit) Chesselet, S.A.Hammer & I.Oliver. Formerly placed in *Ruschia* Schwantes, it is removed from the genus on the basis of a unique suite of characters. The morphology, distribution, ecology and phylogenetic affinities of *Brianhuntleya* are discussed.

Our new genus is named in honour of Prof. Brian John Huntley, Chief Executive Officer of the National Botanical Institute, South Africa, since 1990. We feel that it is appropriate to name this genus *Brianhuntleya* in appreciation of his considerable contribution to the advancement of biodiversity research and conservation in southern Africa.

In recent years a number of new genera have been described in Mesembryanthemaceae, of which several pay tribute to botanists, notably *Ihlenfeldtia* H.E.K.Hartmann (Hartmann 1992); *Hartmanthus* S.A.Hammer (Hammer 1995a) and *Hammeria* Burgoyne (Burgoyne *et al.* 1998). Curiously, all three of these are bitypic.

A live plant in fruit (*Chesselet & Oliver 485*), collected near Worcester, on the road to Robertson, in December 2002, was brought to the Compton Herbarium at Kirstenbosch for identification. The singular combination of characteristics, particularly of the pedicel, calyx and fruit, precluded a suitable generic placement in the current system for mesembs. However, it was necessary to search for a species name, as Louisa Bolus had named most mesembs, and often more than once, during the years of intensive collecting and describing of new species in the first half of the 20th Century, and indeed the plant was finally identified as *Ruschia intrusa* (Kensit) L.Bolus. It is significant that we had trouble finding a 'Bolus name': it didn't occur to us that anyone would ever have placed this plant in *Ruschia*!

The following combination of features distinguishes *B. intrusa* from all other mesembs: 'intruse' calyx tube; unique, finely striate wax cover of the leaves; echinate, highly papillate seed; sigmoid, succulent pedicel that withers, allowing fruit to break off from the mother plant and disperse seed from the well-separated fruit; flat bowl-shaped capsule base enabling rain-splash dispersal in detached fruit (usually found in some multilocular fruit).

Brianhuntleya *Chesselet, S.A.Hammer & I.Oliver,* gen. nov. (Ruschieae Schwantes; Mesembryanthemaceae Fenzl). Type species: *B. intrusa* (Kensit) Chesselet, S.A.Hammer & I.Oliver.

Fruticulus perennis caespitosus repens, radice palari centrali radicibusque vadosis e nodis basalibus enatis; rami prostrati lignosi reliquuis dessicatis parum priorum foliorum tectis. *Folia* trigona connata, basin versus rubicunda, carinata griseo-viridia, tegmine cereo crasso striato, pro parte in lamellas foliis crescendibus delabente, unum vel duo pares foliorum ad extremitates ramulorum brevium. *Flos* solitarius in pedicello longo crasso sigmoideo carnoso, fructu ubi maturo exarescenti desiccanti disrumpentique. *Pedicellus* ebracteatus, sed evolutio pedicelli florisque concurret cum productione paris foliorum quod primo bracteas simulare potest. *Calyx* truncatus, tubum formans, sepalis 5 subaequilongis, 3 membranaceis. *Petala* magenteo-purpurea, uniseriata, staminodia filamentosa nulla; staminum classes staturae tres, stamina basin versus papillata, apicibus roseis, conum centralem circum stigmata formantes, polline pallide flavo; styli subulati, longitudine mediocri. *Nectarium* cristatum annulare (holonectarium lophomorphum). *Fructus* capsula 5-locularis hygrochastica, basi crateriformi, supra elevata; valvae apertae horizontales, corpora claudentia magna, loculorum exitos obstantia, propter texturam spongiosam albida, membranae tegentes centrum fructus versus elevatae, liminibus claudentibus in superficie inferiora distali; dispersio seminum ope ejectionis per membranes tegentes carinae dilatantes divergentes, a laminis dilatantibus distinctae, brunneae, laceratae, in subulam desinentes; alae valvarum nullae. *Semina* rubiginosa, ± 1 mm longa, propter papillas longas echinata.

Perennial, tufted, creeping dwarf shrub with a central taproot and shallow roots arising from nodes at base of plant; branches prostrate, woody, covered with dried remains of previous leaf pairs. *Leaves* trigonous, fused, reddish at base, keeled, grey-green with thick, striate, wax cover that flakes off partially as leaves expand, one or two leaf pairs at ends of short shoots. *Flowers* solitary, borne on long, thick, sigmoid succulent pedicel that shrivels, dries out and breaks off when fruit is ripe. *Pedicel* without bracts, but development of pedicel and flower coincides with production of a leaf pair that in early stages may resemble bracts. *Calyx* truncate, forming a calyx tube, 5 sepals more or less of equal length, 3 membranous. *Petals* magenta-purple, in a single whorl; filamentous staminodes absent; three size classes of stamens, with papillate bases and pink tips, forming a central cone around stigmas; pollen pale yellow; styles subulate, of medium length. *Nectary* crested, annular (lophomorphic holonectary). *Fruit* 5-locular, hygrochastic capsule, base bowl-shaped and top raised; valves opening to horizontal position, closing bodies large, blocking exits of locules, whitish from spongy tissue, covering membranes raised towards centre of fruit, with closing ledges on distal undersurface; ejection dispersal through covering membranes; expanding keels diverging, distinct from expanding sheets, brown, lacerate, ending in an awn; valve wings absent. *Seeds* reddish, ± 1 mm long, echinate from long papillae.

The genus includes a single species:

Brianhuntleya intrusa *(Kensit) Chesselet, S.A.Hammer & I.Oliver*, comb. nov.

Mesembryanthemum intrusum Kensit in Bolus & Kensit in Transactions of the Royal Society of South Africa 1: 151 (1909). *Ruschia intrusa* (Kensit) L.Bolus: 220 (1950). Lectotype: Cape, hills near Robertson, July 1901, *Marloth 4592* (BOL!).

Emended species description

Tufted plant, 70–100 mm high; branches decumbent, woody, old leaves persistent on plant. *Leaves* trigonous, 50–60 × 7–8 mm, grey-green, reddish at bases, waxy, keel indistinct; arising from between 2 pairs of young green leaves in axil of older pair. *Flowers* up to 35 mm diam., spreading; pedicel 30–50 mm long, succulent. *Sepals* 5, of subequal length, 3 membranous, up to 3 mm long; petals up to 17 × 1.5 mm, 1-seriate, pale rose-purple; nectary green, annular and crested; top of ovary raised, convex; stigmas 5, subulate, acuminate, 2 mm long; stamens in 3 rows, 2–4 mm long, pinkish at tips; anthers and pollen pallid. *Fruit* 5-locular, hygrochastic capsule, 7.5–9.0 mm diam., 4 mm deep, valves raised, 4 mm high; seed 1 mm long. Flowers open for a few hours in the afternoon. *Flowering time*: late May–June in cultivation and July in the wild. Figure 3.

Etymology: the specific epithet *intrusum,* from the Latin *intrusus*, is used in the botanical context to describe a form that appears pushed or thrust inwards. In this context Bolus used the term to describe the 'very peculiar truncate somewhat intruse calyx tube' characteristic of this species (Bolus & Kensit 1909).

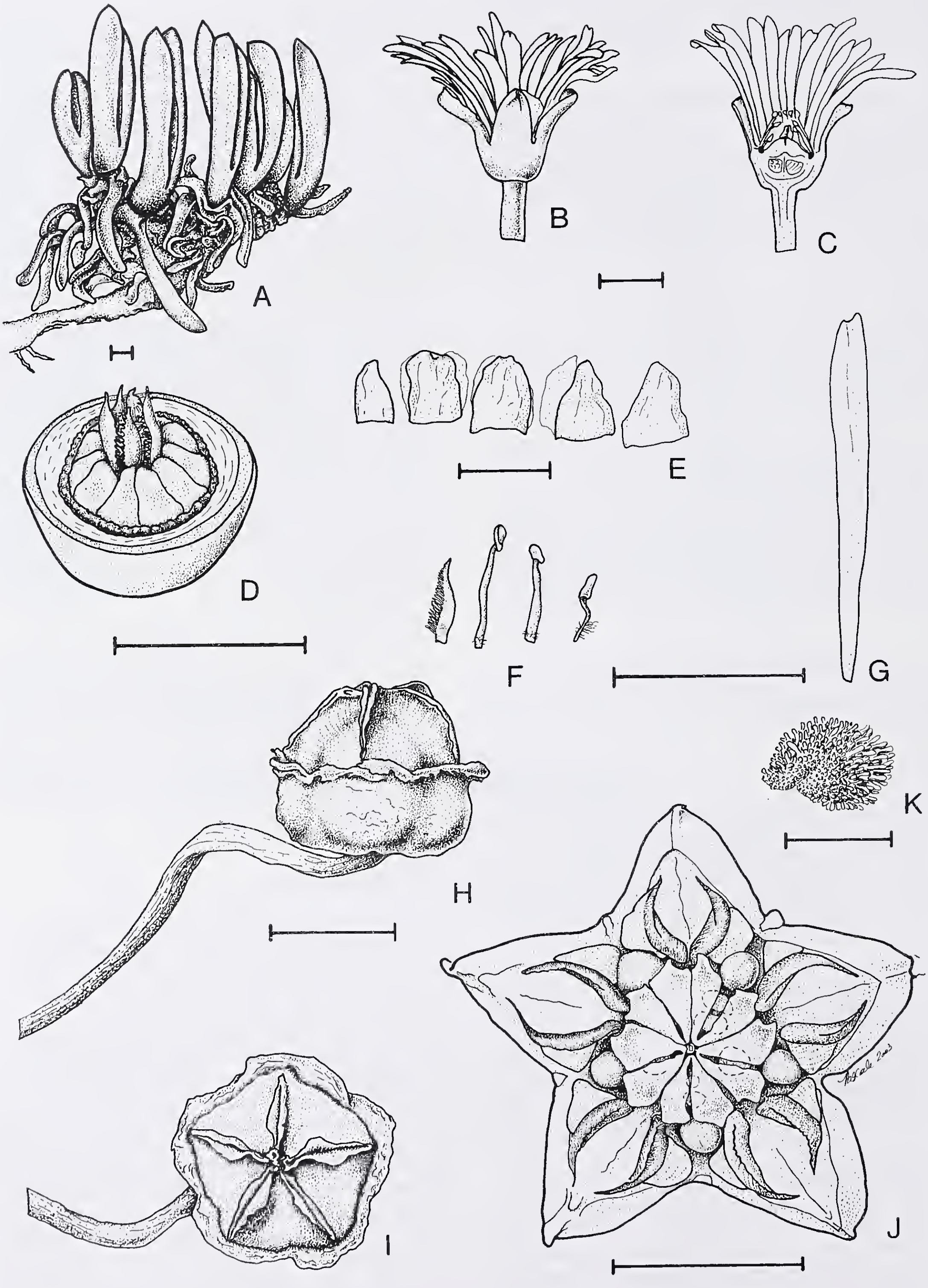

FIGURE 3.—Morphology of *Brianhuntleya intrusa*. A, habit, showing upright leaf pairs and creeping stems with accumulated dead leaves from previous growth; B, flower showing ‘intruse’ calyx; C, l/s flower; D, gynoecium with ring-like beaded nectary; E, five subequal sepals; F, stigma and three size classes of stamens; G, petal from single whorl. H–J, fruit: H, side view showing flat base, raised valves and long, withered pedicel; I, top view; J, open fruit with large whitish closing bodies, covering membranes and expanding keels. K, echinate seed. Scale bars: A–J, 5 mm; K, 1 mm.

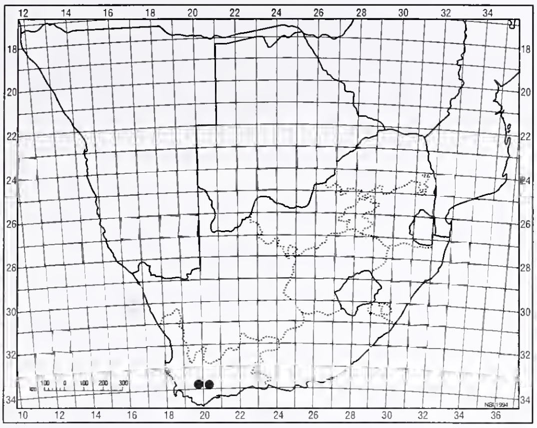

FIGURE 4.—Known geographical distribution of *Brianhuntleya intrusa*.

Distribution and ecology: the genus *Brianhuntleya* is endemic to the Worcester-Robertson Karoo, part of the Succulent Karoo Biome, from which 11 genera and 37 species of mesembs are known (Chesselet *et al.* in prep.). The monotypic genus *Stayneria* L.Bolus is the only other mesemb genus endemic to the Worcester-Robertson Karoo, where it is confined to Renosterveld in the Breede River Valley, from Worcester to McGregor.

B. intrusa is known from populations at Worcester, Robertson, Montagu, McGregor and Bonnievale, all in the Breede River Valley, where it is restricted to eroded Malmesbury Shale sometimes interspersed with small chunks of surface quartzite (Figure 4). Plants grow on low hills at altitudes ranging from 200–250 m, in full sun, with mixed succulent vegetation that includes *Ruschia caroli*, *Adromischus filicaulis*, *Poellnitzia rubriflora* and *Conophytum ficiforme*. Near Bonnievale it grows with *Acrodon purpureostylus*.

In horticulture *B. intrusa* is very resilient, not sensitive to over-watering, and it produces its splendid flowers at a time when most vygies are without flowers. It becomes quite luxuriant if well watered, forming a grey-green ground cover, reminiscent of some species of *Carpobrotus* N.E.Br. It is so undeservedly obscure in horticulture that a recent plant list noted that, until recently, no one had ever purchased it.

With only a few known populations, *B. intrusa* is already in a conservation programme at the Karoo Desert NBG. Live plants were collected in a salvage operation for *ex situ* and *in situ* conservation from a site of planned road works at the Gorees Hoogte Pass near Robertson. Once road works are complete, the area will be restored.

Systematic affinities: when Bolus (née Kensit) described *Mesembryanthemum intrusum* (Bolus & Kensit 1909), she suggested that the new species is affiliated to *M. divergens* Kensit, now *Antegibbaeum fissoides* (Haw.) Schwantes ex C.Weber from near Matjiesfontein, and to *M. brevipes* Schltr., now known as *Argyroderma fissum* (Haw.) L.Bolus, from the Knersvlakte. This latter association seems highly unlikely. However, both Klak *et al.* (2003) and Hartmann (2001a) follow Bolus's suggestion that *B. intrusa* may be closely related to the monotypic *Antegibbaeum* Schwantes ex C.Weber. Echinate seeds, which are characteristic of *B. intrusa*, feature in a number of genera in Mesembryanthemaceae including *Acrodon* N.E.Br., *Antegibbaeum*, *Braunsia* Schwantes and *Namaquanthus* L.Bolus.

It may be deduced from a recent molecular study of relationships in the *Lampranthus* Group (Klak *et al.* 2003), that *B. intrusa* would resolve as a clade with *Hammeria*, *Antegibbaeum*, *Smicrostigma* N.E.Br., *Zeuktophyllum* N.E.Br., *Vlokia* S.A.Hammer and '*Braunsia*' *vanrensburgii* (L.Bolus) L.Bolus. Diagnostic features of the fruit, however, conflict significantly with the proposed grouping of the above genera by Klak *et al.* (2003).

One cannot rule out the possibility that *B. intrusa* may belong to the mysterious '*Calamophyllum*', a genus erected by Schwantes (1927) based on cultivated plants. Species included in *Calamophyllum* were originally described by Haworth in the 1790s under *Mesembryanthemum* and have not been definitely identified since. Problems of correct identification in this genus are not surprising, as descriptions are conflicting and distributions unknown (Jacobsen 1960; Herre 1971; Smith *et al.* 1998; Hartmann 2001b). Some features that may support this possibility include the grey-green leaves of ± cylindrical shape, the long pedicel of *C. teretifolium* (Haw.) Schwantes, the leaves of *C. teretiusculum* (Haw.) Schwantes that may be impunctate (Hartmann 2001b), and the flowers seen in *Mesembs of the World* (Smith *et al.* 1998), as well as the illustration of the ovary with raised top and five stigmas shown in R. Darroll's illustration in Herre's (1971) *Genera of the Mesembryanthemaceae*.

Brianhuntleya grows sympatrically with *Acrodon purpureostylus* (L.Bolus) Burgoyne near Bonnievale, and it is remarkable how easily these plants can be confused with each other, both having similar grey-green leaves with reddish bases, creeping growth forms and detachable fruit. Nonetheless, *A. purpureostylus* is easily distinguished by its unwaxed leaves, *Acrodon*-type flowers (striate pink petals, stamens collected in a cone, plumose stigmas and pale pollen), and shiny orange, well-exposed stems reminiscent of species of *Jordaaniella* H.E.K.Hartmann. When Dehn (1992) revised the Ruschiinae, he annotated specimens of *Ruschia intrusa* as belonging to the genus *Acrodon* although this was later rejected. However, *B. intrusa* has pale pollen and echinate seed in common with species of *Acrodon*.

The transfer of *Ruschia purpureostyla* (L.Bolus) Bruyns to *Acrodon* (Burgoyne 1998) raised much controversy (Klak 2000; Hartmann 2001b). The lophomorphic holonectary of *A. purpureostylus*, shown to be a significant taxonomic character by Chesselet *et al.* (2002), precludes its inclusion in *Cerochlamys* N.E.Br, a genus with a lophomorphic meronectary, as suggested by Hartmann (2001b). The fruit of *A. purpureostylus* is similar to that of *B. intrusa* as it also has a withering pedicel and detaches from the mother plant, unlike the rather solid fruit with thick persistent pedicels of other species of *Acrodon* N.E.Br. The unusual fruit of *A. purpureostylus* either casts some doubt on its current generic placement or highlights strong selection for detachable fruit in their mutual environment. The base is rounded and not flat as in *B. intrusa* and the covering membranes are not as raised or hardened, closing bodies are larger and spongier, the valves open to the upright position (as in other *Acrodon* and *Ruschia* species) and do not fold back to the horizontal position as in *B. intrusa*, thus excluding the possibility of these two species being congeneric.

A link to the *Leipoldtia* Group of Hartmann (1991) is suggested by *Brianhuntleya*'s unique fruit structure and overall resemblance to members of the genera *Cephalophyllum* N.E.Br. and *Cheiridopsis* N.E.Br. The floral resemblance may be more than superficial; it is remarkable how closely the flowers of *B. intrusa* resemble those of a typical 'showy' *Cephalophyllum* and how little they look like those of most *Ruschia* species (those being much smaller, and often bunched). In cultivation, *B. intrusa* crosses with *Cephalophyllum subulatoides* (Haw.) N.E.Br., a Little Karoo species, providing further support for its affinity to members of the *Leipoldtia* Group. The flat, bowl-shaped base is only known from genera such as *Cheiridopsis* and *Cephalophyllum*, however, these genera have multilocular fruits, whereas *Brianhuntleya* has a five-locular fruit. It is indeed a singular entity, and its placement has intrigued mesemb specialists for many years (Hammer 1995b; Hartmann 2001a; Klak *et al.* 2003).

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Other specimens examined

WESTERN CAPE.—3319 (Worcester): Langvlei, (–DC), *Bruyns 9057* (BOL); Robertson, between McGregor and Bonnievale, (–DD), *Glen 624* (BOL). 3320 (Montagu): Bonnievale, (–CC), *R.H. Compton NBG1138/24* (BOL); *J. Lewis NBG1975/33* (BOL).

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FABACEAE

THE CORRECT NAME FOR *ACACIA MONTANA*

The author published a new species, *Acacia montana* within the *Acacia karroo* complex in Coates Palgrave (2002). Bentham (1842) used this specific epithet for an *Acacia* species in Australia that was transferred to *Racosperma* Martius by Pedley (1987). The Australian species is now known as *R. montana* which is the base name for *A. montana*. Therefore *A. montana* is a homonym and the correct name is:

Acacia theronii *P.P.Swartz*, nom. nov.

A. montana P.P.Swartz in M. Coates Palgrave, Keith Coates Palgrave Trees of southern Africa, edn 3: 19, 289 (2002) non *A. montana* Benth: 360 (1842).

TYPE.—KwaZulu-Natal, 2831 (Nkandla): Hlabisa Dist., Feb. 1976, (–BB), *Swartz 178* (PRE, holo.; PRU).

Acacia theronii is named after Prof. G.K. Theron, previously from the Botany Department of the University of Pretoria, who did many years of research on the vegetation of the Loskopdam Nature Reserve, where this

FIGURE 5.—*Acacia theronii* P.P.Swartz, *Codd 2009, Acocks 13077*, ± 18 km SE of Hlabisa, KwaZulu-Natal.

species is found. The author investigated the *Acacia karroo* complex in detail for many years and realised that this new taxon is well defined (Swartz 1982). It is a tall, sleder tree, branching high above the ground, with a relatively pale trunk (Figure 5). It is well adapted to grow in dry and very hot areas and is always associated with shale rock formations. It has the ability to revive well after fire. The wood is dense, hard, compact and relatively heavy. Chemical analysis of the wood confirms that it is a separate taxon from *A. karroo* and *A. natalitia* (Malan & Swartz 1995). The leaves of *A. theronii* have a robust, mat appearance, as the leaflets (pinnules) are relatively large and densely packed with a thick wax layer as seen under the electron-microscope (Swartz 1982). Anatomy of young stems show that the periderm actively divides at an early stage, and new cells are constantly being formed, pushing the older ones off, and resulting in a relatively thick and powdery bark (Swartz 1982). Chemical analysis of the fragrances of the flowers, the seed and leaves done by Brain (1986, 1987), also show evidence that this is a well-defined new species.

Acacia theronii was found growing on the hills of Hlabisa in northern KwaZulu-Natal, southeast of Vryheid, as well as on the hills around Groblersdal in Mpumalanga in the Loskopdam Nature Reserve. It occurs in a transitional area in Umfolozi, Hluhluwe and the Lebombo Mountains and on the bushy hills around Pongola, Magudu, Mkuze and Nongoma (Ross 1975).

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CLEVEACEAE-MARCHANTIALES

SAUTERIA NYIKAENSIS, A NEW LIVERWORT SPECIES FROM MALAWI

INTRODUCTION

In the Cleveaceae the dorsal air pores of the thalli are simple and the radial walls of the surrounding cells are often thickened. Three genera have traditionally been grouped together in this family, namely *Athalamia* Falc., *Peltolepis* Lindb. and *Sauteria* Nees. *Peltolepis* and *Sauteria* have not been reported from Africa, but *Athalamia* (formerly *Clevea*) has long been known from this continent, with two species that occur here, namely *A. spathysii* (Lindenb.) Nees and *A. pulcherrima* (Steph.) Hatt. (Vanden Berghen 1965). A third species, *Clevea* (*Athalamia*) *crassa* Trabut, from the Atlas Mountains (Magreb), is considered to be a *nom. inval.* (Grolle 1976).

Sauteria is a small genus of ± five (Bischler 1998) or six species (Schuster 1992), although some authorities recognize only three species worldwide (Gradstein *et al.* 2001). The

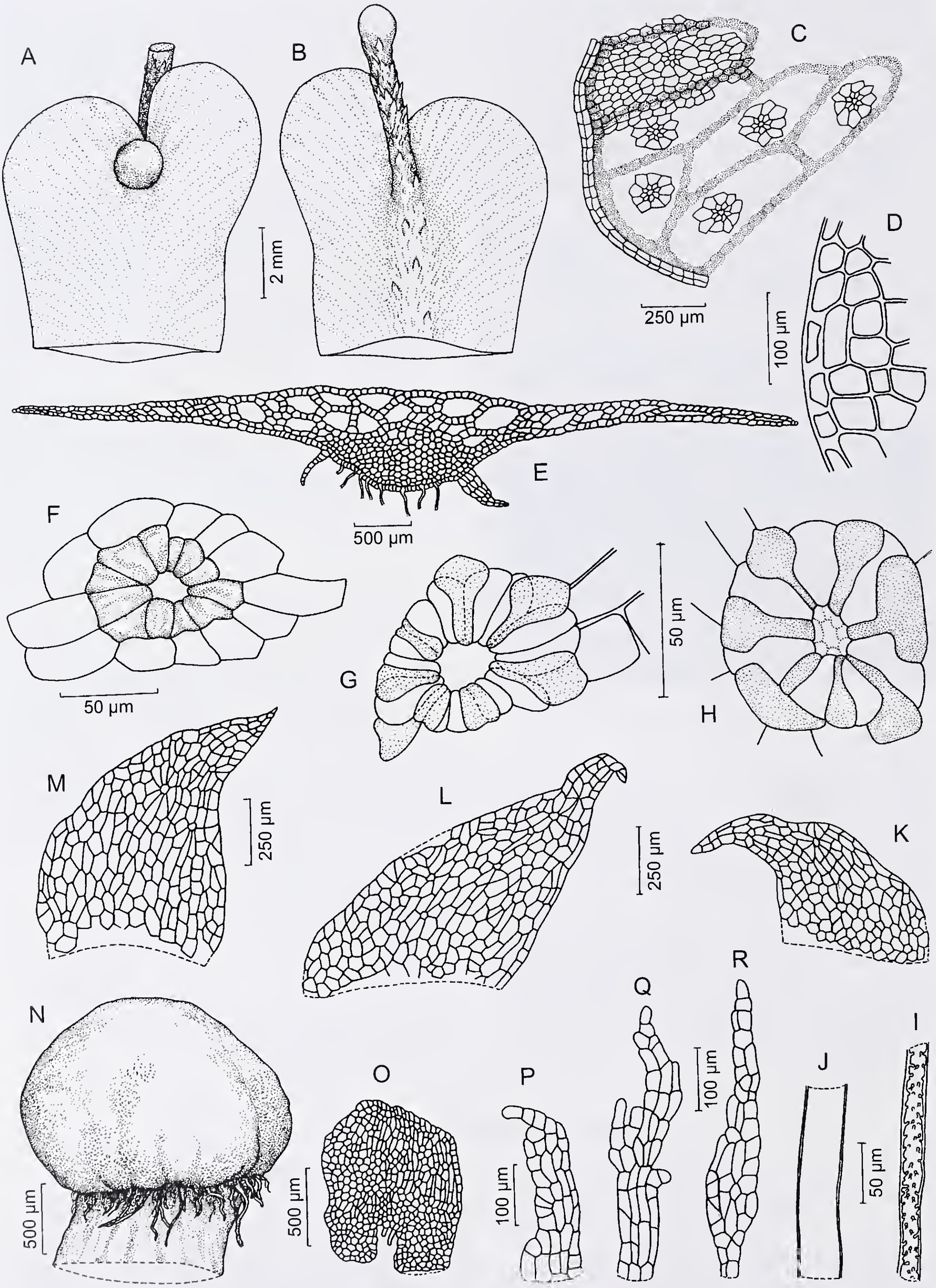

FIGURE 6.—*Sauteria nyikaensis, Koekemoer 1874.* A–E, thallus: A, dorsal face with young female receptacle, stolon cut off apically; B, ventral face with stolon uncut, covered with scales and rhizoids; C, air chambers partly exposed beneath dorsal epidermal cells and air pores surrounded by thickened cells; D, marginal cells and some dorsal epidermal cells; E, c/s. F–H, air pore and surrounding cells from above. I, J, rhizoids: I, tuberculate; J, smooth-walled. K–M, ventral scales; N, young female receptacle from side; O, c/s stalk with single rhizoid furrow; P–R, paleae. Drawings by M. Steyn.

genus is widespread, but is restricted to high mountain environments, often above 3 000 m, although it also occurs at lower elevations on islands (Gradstein *et al.* 2001). In Europe, Russia, Siberia, Tibet, the Himalayas and northern Japan, the distribution of its members is arctic or montane. Its western range includes areas in Iceland, east and west Greenland, as well as east and west Canada (Müller 1951–1958). Hitherto, the only known records in the southern hemisphere are those from the Andes of Peru, northern Argentina and Chile, as well as the Galapagos Islands, where it was found at an altitude of about 1 200 m (Gradstein *et al.* 2001).

During April 2000, an unusual thallose liverwort was collected on the Nyika Plateau at an altitude of 2 343 m, on soil, in a cavity under a rock overhang. Unfortunately, neither of the two female receptacles present is mature, and antheridia are absent. Nevertheless, in order to draw attention to this plant, it is described here and has been referred to the genus *Sauteria* for the following reasons: 1, the thalli are light green and fragile, the assimilation tissue is spongy and there is no trace of pigmentation; 2, the cells surrounding the simple air pores are strongly thickened; 3, the air chambers are empty, lacking both filaments and papillae, medianly in 2 or 3 layers and, visible beneath the epidermal cells in the wings, are the parallel outlines of what appears to be a single layer, obliquely orientated toward the thallus margins; 4, the ventral scales do not extend to the thallus margins; they are hyaline, with a single, tapering appendage, and are arranged in ill-defined rows, mostly confined to the prominent midrib; oil bodies are very rare and apical slime papillae are absent; 5, the female receptacle originates from a deep notch at the apex of the thallus; 6, in cross section the stalk of the receptacle has a single rhizoid furrow, whereas *Athalamia* species have none and *Peltolepis* species have two.

According to Schuster (1992), '*Sauteria* is separated from the other two genera of the Cleveaceae by one absolute feature (solitary rhizoid furrow of carpocephalum stalk)'. He also mentions 'distinct, scattered oil cells' in the ventral scales, in some (but not all) cases, adding that isolated ventral scales in Greenland *Sauteria alpina* often lack oil cells. Shimizu & Hattori (1954) describe the oil cells in *S. alpina* as 'scattered in the ventral scales and the dorsal epidermis of thallus, rare'. In their description of *S. alpina* var. *japonica* (later elevated to *S. yatsuensis*), they note that, 'oil-cells scattered in ventral tissue of thallus and bractlets of female receptacle (and also in ventral scales of thallus?), very rare', their question mark clearly indicating uncertainty. In a later description of *S. alpina*, Hattori & Shimizu (1955) remark that 'oil-cells rare, scattered in ventral tissue, ventral scales and bractlets'. They do not, however, illustrate oil cells in their 'Text-fig. XXI', although figs F–H of the ventral scales show groups of 5–7 cells surrounding a much smaller central cell, which does not contain an oil body. This is also seen in Figure 6K–M of the Nyika plant. Oil bodies in *Sauteria* have been observed to be long-persisting; those in the scales of *S. alpina*, leg. *S.O.Lindberg* & *E.Rettig* (held at PRE), are still present 120 years after collection.

Sauteria nyikaensis *Perold*, sp. nov.

Thalli magnitudine media vel sat magna, apice semel dichotome ramificantes, interdum irregulariter; laete virides, sine pigmento, fragiles spongiosique. Cavernulae aeriae, circumscriptione clare visibile, in medio thalli parallele, apicem versus dispositae, sed marginem thalli versus oblique dispositae. Pori dorsales non elevati, simplices, ab 1 vel 2 annulis concentricis cellularum circumscripti, pro parte vel pro parte maxima incrassationibus conspicuis tecti. Squamae ventrales hyalinae appendiculo acuminato non semper manifesto, in seriebus incertis supra costam dispositae. Costa saepe producta stolonem magnum geotropicum formans. Antheridia non visa. Receptaculum gynoeciale immaturum, in incisura apicali setae brevi tereti, sulco uno rhizoidali insidens. Guttae olei omnino absentes, semel tantum in squama ventrali visae.

TYPE.—Malawi, 1033: Nyika National Park, Jalawe viewpoint, (–BD), on soil, in a cavity under rock overhang, at altitude 2 343 m, 3 April 2000, *Koekemoer 1874* (PRE, holo.) with *Lunularia cruciata* (L.) Dumort. ex Lindb. and *Plagiochasma eximium* (Schiffn.) Steph.

Thalli prostrate, in crowded patches, obovate, apically notched or incised, on either side with rounded lobes (Figure 6A, B), continuing sometimes as smaller lobes along slightly decurved (Figure 7A) attenuate margins; medium-sized to fairly large, up to 12 mm long and 5–9 mm wide distally, narrowing gradually or abruptly up to ± 4 mm wide proximally, branching dichotomously once, but in young plants often irregularly or rather diffusely; light green, without any pigmentation, margins colourless; fragile and spongy, with clearly visible outlines of elongated, empty air chambers medianly running parallel toward apex, but soon becoming obliquely orientated toward thallus margins (Figure 6C), each one apparently opening by a simple air pore; along dorsal midline, slightly concave and not grooved, laterally margins acute, flanks sloping obliquely, ventral face medianly keeled with a prominent midrib, rounded distally but flattening proximally, covered with rhizoids and ill-defined rows of hyaline scales; midrib rarely branched at its apex, ensuing laminae irregularly shaped, most commonly continuing growth distally and occasionally proximally as well, forming very large tuberous, geotropic stolons (Figures 6AB; 7D), up to 850 μm diam., filled with starch grains. Dried plants with flanks sometimes flat, incurved or ascending.

Dorsal epidermal cells rarely chlorophyllose, unistratose, thin-walled, without trigones, 4- to 6-sided, shorter than wide, generally 30–45 × 60.0–72.5 μm, in cross section 32.5–40.0 μm thick; margins unistratose, with 2 juxtaposed cell rows (Figure 6D), mostly rectangular, others 5-sided, outermost cells 22.5–50.0 × 15.0–32.5 μm, some with thickened walls between adjoining cells; second row of cells 4- or 5-sided, 22.5–45.0 × 27.5–45.0 μm, walls not thickened; air pores (Figures 6F–H; 7B; 8A) one per air chamber, not raised, simple, oval or rounded, 10–15 × 10–20 μm, with or without faint inner ring of small cells and then bounded by 1, occasionally 2 concentric rings of cells, variable in number, and covered partly to sometimes almost entirely by conspicuous thickenings, 15–25 × 12.5–20.0 μm, also obscuring several of the radial cell walls, width of air pore together with surrounding cells 62.5–100.0 μm; row of dorsal epidermal cells adjoining thickened cells often

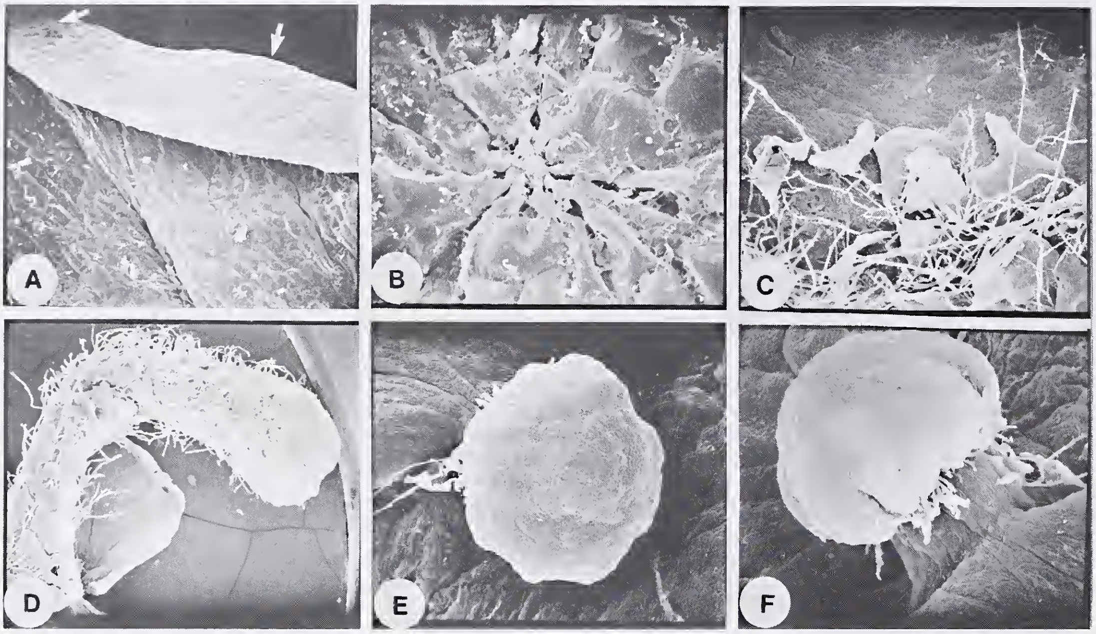

FIGURE 7.—*Sauteria nyikaensis*, *Koekemoer 1874*. SEM micrographs. A, margin of dorsal face of thallus decurved over lateral part of ventral face, arrows indicating positions of some dorsal air pores with thickenings; B, thickened cells around contracted air pore in concentric rings, partly shown; C, irregular rows of ventral scales mostly over midrib, between rhizoids; D, massive ventral stolon with scales and rhizoids, partly overlying apical part of ventral face of thallus; E, young female receptacle from above; F, young female receptacle from side. A, × 58; B, × 430; C, × 18.5; D, × 8.5; E, × 18; F, × 21.

somewhat smaller than average, partly arranged in a concentric ring, occasionally the thickenings extending slightly onto a few of them as well.

Assimilation tissue, as seen below and through dorsal epidermis, with parallel outlines of empty air chambers 200–350 µm apart, running obliquely across wings to margins of thallus, partitioned in wings by slanting, unistratose cross walls at intervals of up to 600 µm between them, at thallus margins air chambers somewhat smaller; in cross section (Figure 6E), thallus over midrib 700–1150 µm thick, ± upper half with polyhedral air chambers in 2 or 3 layers, 65–175 × 150–220 µm, with lower ones smaller, unistratose walls consisting of chlorophyllose cells, spherical or ovoid, 37.5–50.0 × 25.0–42.5 µm; storage tissue occupying ± $^1/_6$ of width of thallus medianly and ± 12 rows of cells in lower half of thickness of thallus, decreasing laterally, soon disappearing and flanks bounded beneath by ventral epidermis only, cells crowded together, angular, 27.5–40.0 × 50–65 µm, no sclerotic cells, oil bodies or mucilage cavities present; rhizoids densely covering midrib, fewer beneath wings, some smooth (Figure 6J), 27.0–47.5 wide, others pegged (Figure 6I), 15–25 µm wide. *Ventral scales* (Figure 6K–M), hyaline, in 2–4 poorly defined rows over midrib and extending onto adjacent ventral face of thallus (Figure 7C), also on continuation(s) of midrib as geotropic stolon(s) (Figures 6B; 7D); inconspicuous, asymmetrically triangular, one side obliquely rounded, margins entire, tapering gradually and not constricted where joined with acuminate, apically pointed and not sharply differentiated appendage, 725–1025 µm long (including appendage), width across base 375–725 µm, cells 4–6-sided, 45–75 × 30–45 µm, in each scale 1–3 groups of cells surrounding 1 much smaller, central cell, not containing an oil body; oil bodies very rare (Figure 8A, B), 22.5–25.0 × 20.0–27.5 µm, light brown and finely granular.

Monoicous? Antheridia unknown. *Gynoecial receptacle* terminal, raised on short stalk, (Figures 6N; 7E, F) at crotch of apical incision up to 2.5 mm long, separating 2 thallus lobes, immature, rounded above, ± 1675 µm wide, with 8 lobes below, air pores not seen, but may develop later, as air chambers visible in cross section of receptacle, a single archegonium also seen; stalk terete, with one rhizoid furrow (Figure 6O), 625 µm long at this stage of development, 875 µm wide, without assimilatory strip, naked below, but with paleae at apex; paleae elongated and narrow (Figures 6P–R; 9B) 375–800 × 75–120 µm, inner cells 25–40 × 12.5–25.0 µm, with 1 to 3 papillae apically and sometimes 1 at margin, thicker-walled at tip. *Chromosome number* for the genus *Sauteria*: n = 36 (Müller 1951–1958; Hattori & Shimizu 1955, count by Dr S. Tatuno for *Sauchia japonica*, later transferred to *Sauteria yatsuensis*; Bischler 1998). The Nyika material was no longer living when examined, and a chromosome count could not be done.

DISCUSSION

In the absence of antheridia, the single archegonium seen in the above specimen, would not have been fertilized. The development of antheridia may have been delayed for some reason, or else they had already disappeared. Bischler (1998) states that in families of the Marchantiales with archegoniophores other than the Marchantiaceae, the stalk elongates after fertilization. In the Nyika plant, however, the stalk is still very short, almost sessile, and fertilization had not taken place.

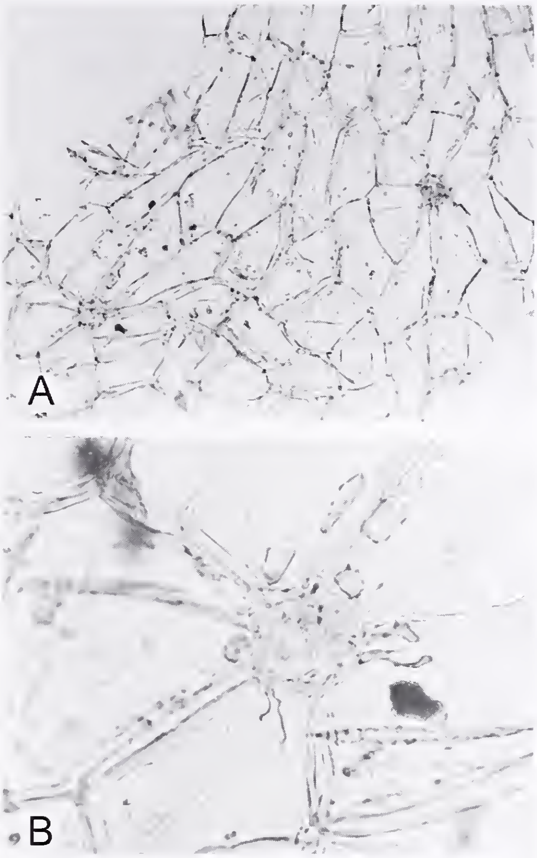

FIGURE 8.—*Sauteria nyikaensis, Koekemoer 1874.* LM micrographs. A, part of ventral scale with 2 oil bodies; B, much enlarged micrograph of one of the oil bodies. A, × 198; B, × 790.

Because of the delicate structure of the thalli, the plants are thought to be drought intolerant and to perennate during the dry season by means of the tuberous geotropic stolons.

At the site in northern Malawi (Figure 10), where the plant was collected near the Jalawi View Point, it grew on calcareous soil containing slivers of mica, in a small, cave-like cavity at the base of a large rock. Not much direct sunlight could have reached it there, but species of *Sauteria*, except for *S. chilensis*, lack secondary pigmentation even when growing in open, strongly illuminated sites (Schuster 1992). Shimizu & Hattori (1954) do not regard the presence of thickened radial walls around the dorsal air pores as being of generic value, since they had observed pores with both thickened and thin radial walls on the same plant. All the air pores in the Nyika specimen had thickenings, not just on the radial walls but partly or entirely covering the cells surrounding them, somewhat like those in *Athalamia pulcherrima*, as illustrated by Vanden Berghen (1965). When stained with periodic acid-Schiff's (PAS) reaction (Jensen 1962), the thickenings became intensely pink, much more so than the rest of the tissues.

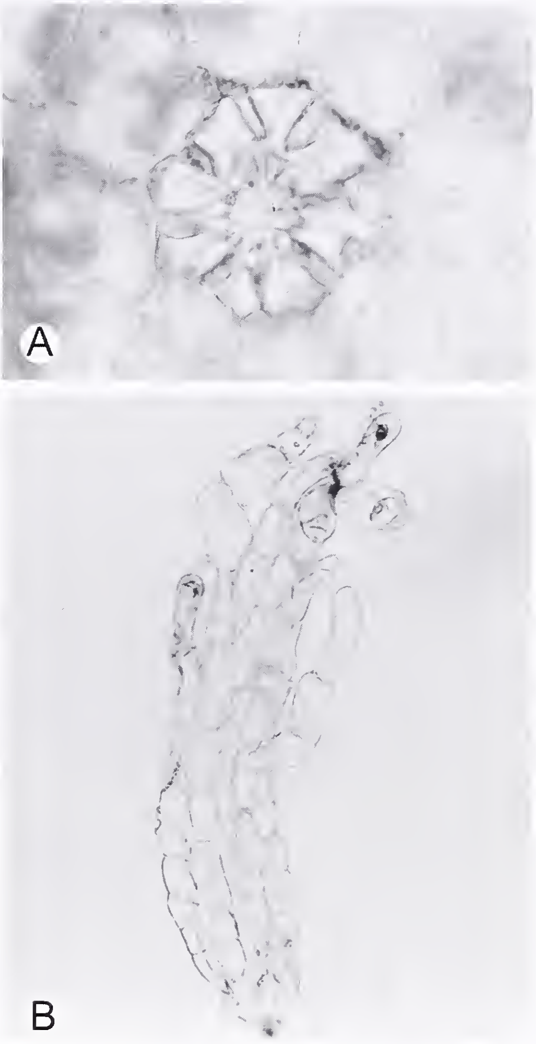

FIGURE 9.—*Sauteria nyikaensis, Koekemoer 1874.* LM micrographs. A, dorsal air pore with thickenings on surrounding cells; B, palea. A, × 500; B, × 100.

Bischler (1998) states that the genera *Athalamia*, *Sauteria* and *Peltolepis* are traditionally grouped in the same family, the Cleveaceae, but adds that, 'other characters argue against such a classification'. She does not elaborate further.

Sauteria nyikaensis is separated from the other species in the genus by collectively considering the following characters listed in Table 1.

The genus *Sauteria* was first described by Nees (1838) and named for the Austrian physician, Anton E. Sauter, 1800–1881, who also collected and studied liverworts.

If more material of *Sauteria nyikaensis* with ripe sporophytes is collected, the above description will, undoubtedly, have to be emended.

ACKNOWLEDGEMENTS

I wish to sincerely thank the curator of PRE, Dr M. Koekemoer, for collecting this specimen while on a South-

TABLE 1.—Comparison of some characters of *Sauteria alpina*, *S. chilensis*, *S. nyikaensis* and *S. yatsuensis*

	S. alpina (Schuster 1992)	*S. chilensis* (Hässel de Menéndez 1963)	*S. nyikaensis* (Perold 2003)	*S. yatsuensis* (Hattori & Shimizu 1955)
Distribution	Central and northern Europe, Yugoslavia, Siberia, Norway, Sweden, Finland, Iceland, Greenland, Alaska, British Columbia, Alberta	Andes of Peru, northern Argentina and Chile; Galapagos Islands	Nyika Nat. Park, Malawi	Mt Rishiri, Rishiri Island, Hokkaido, northern Japan
Thallus				
colour	light green, margins decolorate	dark green, margins & ventral face purple	light green, no pigmentation	pale to light or dull green
size	8–17 × 3–5 mm	6–12 × 1.5–2.5 mm	up to 12 × 5–9 mm distally	10–15 × (3–)5–7 mm
branching	simple or 1–2 × dichotomous	3–4 × dichotomous	dichotomous or irregular	sparsely dichotomous
segments	lingulate	branches with apical innovations	rounded lobes	
apex	deeply emarginate	furrowed	notched or incised	
texture	fleshy, ± soft		fragile, spongy	‘not so firm’
margins	thin, translucent, ascending	purple	colourless, 2 juxtaposed cells unistratose, attenuate	
dorsal epidermis	strongly areolate	cells with chloroplasts	unistratose, cells thin-walled	
pores	± elevated, bounded by 5–7 cells, radial walls thickened	not raised, bounded by 5 or 6 cells, radial walls thickened	not raised, bounded by up to 12 or 13 cells, mostly covered by thickenings	radial walls of cells not so thickened, often thin and indistinct
air chambers	inflated, polyhedral, (2)3(4) layers	1(2) layer(s), narrow-rectangular	polyhedral, 2 or 3 layers	polygonal
Ventral scales	not projecting at thallus margins	extending to thallus margins	over midrib and occasionally on adjacent ventral face	hardly reaching thallus margins
rows	irregular, 3–6	in 2 irregular rows	2–4 poorly defined rows	in 3–5(6) irregular rows
colour	hyaline	reddish black or decolorate	hyaline	colourless
shape	asymmetrically ovate-lanceolate	base triangular	asymmetrically triangular	ovate or lanceolate
appendage	acuminate to longly acute	ciliate, basally constricted or not	acuminate, not sharply differentiated	narrowed to 1-celled apex
marginal slime papillae	present, clavate	ephemeral	absent	usually present
oil bodies	scattered in scale body	in 1 or 2 isolated cells	very rare	rare
Geotropic stolons	not mentioned	not mentioned	present, prominent	not mentioned
Androecia	ill-defined group behind female stalk	behind female receptacle	not seen	just below female receptacle or on different branch
Gynoecia	from deep apical notch	at apical bifurcation	from deep apical notch	disc non-convex, lacking pores
stalk	colourless, up to 15 mm long	yellow-green, 2–8 mm long	immature, only 625 µm long	
paleae	none at base, few at apex		narrow and elongated, at apex	

Note: there is little information about *S. spongiosa* Kashyap (1929) from middle and main Himalayas, Kashmir, or about *S. inflata* Gao *et al.* (1981) from Tibet.

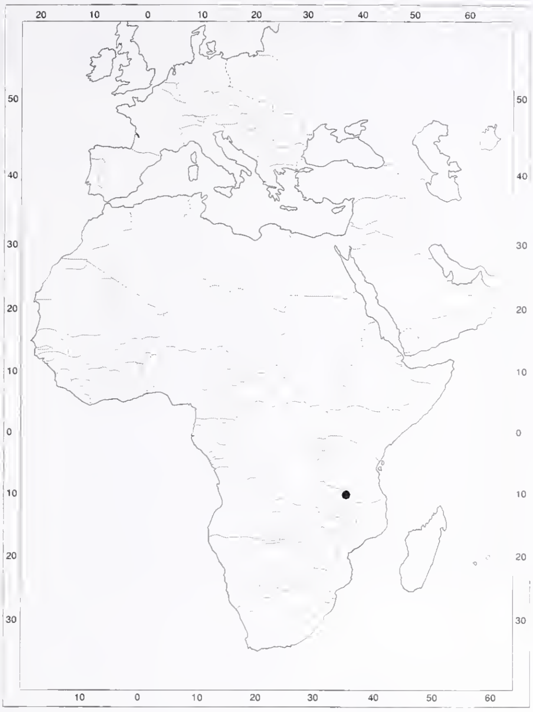

FIGURE 10.—Locality of *Sauteria nyikaensis* in Malawi.

ern African Botanical Diversity Network (SABONET) Expedition to the region; also Dr David Long for advice. The referees, the artist, Ms M. Steyn, and the typist, Ms D. Maree, are warmly thanked for their valued contributions, and so is Dr H.F. Glen for the Latin diagnosis.

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Inflorescences of *Cliffortia* L. (Rosaceae) and related vegetative branching patterns

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Keywords: branching, *Cliffortia* L., dichogamy, dioecy, herkogamy, inflorescence, monoecy, morphological plasticity, sex change

ABSTRACT

The inflorescence construction of eight species, representative of the types found in the 119 species of the rosaceous genus *Cliffortia* L. is described, based on stereo microscopic examination of fresh and dried specimens, combined with extensive field observations. In its simplest form the inflorescence is a reduced short shoot, bearing a lateral ebracteate flower and a potentially viable apical bud. Variations in the basic structure can be in the number of flowers, the mix of the sexes of the flowers and the number and type of short shoots as primary, secondary and tertiary axes. A high incidence of structural plasticity of the inflorescence occurs. This can be either throughout the development of the inflorescence or only at the onset of the vegetative stage. These changes occur in the short shoot(s) constituting the axes of the inflorescence, causing either an increase in the length of the internodes, apical proliferation of the axes or a combination of these two effects. A specific combination of changes is linked to a specific inflorescence type. The vegetative elements of the inflorescence thus modified, are retained as an integral part of the vegetative branching system, with extensive influence on the branching pattern. This can also result in the predominance of one sex over the other over time, so that an individual, initially of the one sex, can become one of the opposite sex by the end of the season. Erroneous interpretation of a single point in the process of sex change as if it is a permanent state of sexuality, led to the prevalent acceptance of dioecy as the norm for the genus. Monoecy with dichogamy (or herkogamy at inflorescence level) was observed in this genus, as in many other wind-pollinated taxa.

CONTENTS

INTRODUCTION

Cliffortia L. includes 119 species of woody evergreen plants. The genus was last revised by Weimarck in 1934, and most of the publications since then have dealt with the description of occasional new species (Weimarck 1940, 1946, 1953, 1959; Oliver & Fellingham 1991, 1994; Fellingham 1993a, b, 1994, 1995), or developed the taxonomy to incorporate new species (Weimarck 1946, 1948). Koutnik (1987) listed the genus as being the largest genus of wind-pollinated plants in the Cape flora, but added the comment that many of these species might be apomictic. This has not yet been corroborated. Oliver & Fellingham (1994), in a detailed discussion of the inflorescence construction and phenology of section *Arborea* in *Cliffortia* hinted at the biological and morphological complexity found in the genus.

Cliffortia is a typical member of the temperate Cape Flora, and with ± 114 species in the southwestern tip of South Africa (Fellingham 2000). It is one of the 13 genera in the remarkably rich Cape Floral Region (CFR) with more than 100 species (Goldblatt & Manning, 2000). Although the genus is found from sea level to the highest mountain summits in the CFR, further north it is restricted to high altitude areas. At least eight species are found in the Drakensberg of Lesotho and KwaZulu-Natal (Jacot Guillarmod 1971; Hilliard & Burtt 1987). Only three species occur in Zimbabwe and Malawi (Mendes 1978), one of which reaches north to the East African highlands (Graham 1960).

Cliffortia is usually included in section *Sanguisorbeae*, on account of the reduced carpel numbers, predominantly uni-ovulate ovaries and missing petals (Melchior 1964; Takhtajan 1997). The entire section including *Cliffortia* is wind pollinated and has, therefore, unisexual and obscure flowers with stigmas or stamens as their most prominent parts, and the flowers are often variously aggregated into dense spikes or heads. Eriksson *et al.* (1998) found the elements of the section *Sanguisorbae* to have strong links with each other and not simply an artifact of convergent evolution. A phylogenetic analysis of this section, based on ITS sequence data (Helfgott *et al.* 2000), indicated that some species of a paraphyletic genus, *Sanguisorba* (a northern hemisphere genus), are the closest relatives of *Cliffortia*. These in turn are related to *Acaena* and *Polylepis*, both, like *Cliffortia*, southern genera. The other African wind-pol-

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linated genera, *Hagenia* and *Leucosidea*, are sisters to each other, but are rather more distantly related to *Cliffortia*. Furthermore, they differ morphologically by the presence of petals. Morphological data are thus consistent with the classifications proposed by Melchior (1964) and Takhtajan (1997).

Cliffortia is remarkably uniform in flower structure, but diverse in leaf morphology. *Aspalathus* (Fabaceae) and *Anthospermum* (Rubiaceae) exhibit morphological convergence in vegetative parts with *Cliffortia*. Nineteen species of *Aspalathus* are indistinguishable in the sterile state from as many species of *Cliffortia*, except for the absence of leaf sheaths and stipules (Dahlgren 1971). Several species of *Anthospermum*, sharing habitats with *Cliffortia* species, are indistinguishable from these species, but for their opposite leaves. The similarity extends beyond the presence of leaf sheaths and stipules to include flower morphology, both having small unisexual flowers, prominent calyx lobes and remarkably similar fruits.

To date, the inflorescences of *Cliffortia* have received scant attention. Weimarck's (1934) rather superficial descriptions of the inflorescences indicate that he misunderstood the basic construction of the inflorescences (not difficult, if working with limited material, especially if most of it is herbarium material, which has to be treated with great care). This lack of understanding of the inflorescence construction affected the interpretation of the patterns of sexuality in *Cliffortia*. Often only overtly male or overtly female plants are found in any population at any specific time, leading to suggestions that at least some of the species may be apomictic (Koutnik 1987), and the general impression that most species are dioecious. Weimarck (1934) noted that 'the distribution of male and female flowers has been shown to be very irregular so that, as far as is known, not less than 47 species out of 78 have been found at least capable of being monoecious'. Nevertheless, he still held the notion of dioecy as the rule for the genus.

These findings established the existence of a wide range of inflorescence types in *Cliffortia*, varying from solitary flowers to fascicled flowers and highly condensed cones containing large numbers of flowers. In this paper we wish to address several questions: (a) is there a common basic construction discernable in the different inflorescences of *Cliffortia*; (b) can these common units be used to compare different types of inflorescence construction; (c) how can this account for the apparent dioecy in the genus; and (d) how does the inflorescence type influence the branching pattern?

Terminology

The terminology we use is largely derived from Weberling (1983, 1989). Inflorescences refer to 'the shoot system which serves for the formation of flowers and which is modified accordingly' (Troll in Weberling 1989). On a single plant or branch system, separate inflorescences are separated by sets of vegetative branches. Short shoots [brachyblasts in Weimarck (1934)] are defined here by their short internodes. A short shoot is not, however, always a permanent element of the plant morphology but can disappear through abortion, or transformation into a long shoot. Neither is it always a patently visible structure but can be completely and permanently hidden in the axil of its subtending leaf. The matrix for the flower-bearing short shoots is the long shoot, which is a vegetative shoot with long internodes. Ordinary vegetative leaves on the long shoots subtend these fertile short shoots. The main involvement of the short shoot is with flower bearing, with the flowers either bracteate or ebracteate but never subtended by ordinary vegetative leaves. Vegetative short shoots do occur, but only rarely and then they bear ordinary vegetative leaves, as long shoots do. A short shoot is thus a permanent or temporary, patent or obscure shoot with short internodes, has the main function of flower bearing and occurs in the axil of a vegetative leaf on a long shoot, or rarely on a vegetative short shoot. Such short shoots are then equivalent to 'florescences'. A group of florescences aggregated on a vegetative short or long shoot would constitute a 'synflorescence'. Where several florescences are adjacent, they form double racemes or a diplobotryum.

The inhibition zone lies directly below the inflorescence where the formation of florescences is inhibited, and which is therefore sterile. Axillary buds in the inhibition zone need to have at least the potential to make florescences, but are prevented from doing so by the actual inflorescence. By contrast the proliferation zone is above the synflorescence, and occurs where the florescence apex grows out and returns to vegetative growth (Weberling 1989).

Vegetative leaves are usually borne on long shoots, and never subtend flowers. Since floral bracts are recognized as being different from vegetative leaves, the correct identification of these is important. Floral bracts are defined as subtending flowers, but the loss of true bracts may lead to the first leaf below a flower being vegetative, thus making the application of the definition potentially misleading. It therefore seems more practical (though not typologically correct) to recognize bracts as being morphologically different from vegetative leaves. This identification is important, as florescences are defined as being subtended by vegetative leaves (rarely modified), and as containing floral bracts.

In spite of the fact that Weberling's (1989) new terminology had been used to describe the inflorescence in *C. conifera* (Oliver & Fellingham 1994), we have been reluctant to use it in this paper. His definition of a raceme or botrys (botryum?) as having 'clearly developed internodes' and 'stalked flowers', seems to preclude its application to the short shoot inflorescence typical in the genus *Cliffortia*. It would appear that Weberling's earlier (1983) definition of long shoots and short shoots in terms of their respective function is more appropriate to the subject of this paper.

MATERIALS AND METHODS

Observations on inflorescence structure were based on both fresh and dried specimens, and where possible, collections of fresh material were made repeatedly from the same populations, over a season or more. Fertile branches were dissected, examined and sketched with the aid of a stereo microscope fitted with a camera lucida. The dried material was softened, by boiling and soaking in diluted dishwashing solution before dissection. The majority of drawings were done using the camera lucida, but larger, fresh specimens were drawn free-hand.

Species were selected to reflect the diversity of inflorescence structure in the genus. The most specialized are the three cone-bearing species, *C. conifera, C. dichotoma* and *C. arborea*. A highly condensed inflorescence, though with an amazing plasticity, is found in *C. odorata*, which, furthermore, appears to have no short shoots. In *C. heterophylla* the inflorescence is clearly demarcated and initially condensed but extremely plastic and impermanent. The multiflowered form of the short shoot inflorescence, with bracteate flowers, is represented by *C. ruscifolia*. The apparent lack of short shoots (and flowers) in *C. crenata*, makes it an interesting and important subject. *C. nivenioides* is an exceptional and therefore very interesting species for two reasons. It has a preponderance of short shoots, the majority of which are vegetative and the rarer fertile ones appear to bear single flowers directly in the axils of ordinary vegetative leaves.

RESULTS

1. *Cliffortia nivenioides* Fellingham

This species is known from the type locality only: a very discrete locality on an open sunny marsh at an altitude of almost 2 000 m, north of Blesberg in the Swartberg Mountains. The general appearance of this small shrub is that of a compact bunch of long branches emerging from a central point. These long branches are themselves sparsely branched to totally unbranched. The leaves are arranged imbricately on short shoots to form flat, slightly elongated fans. The combined effect is that of a species of the genus *Nivenia* Vent. (Iridaceae) (Figure 1A), hence the derivation of the specific epithet.

Flowers occur on the apical short shoots only, or rarely also on one or two lateral short shoots just below the apex. Each flower appears to be subtended by an ordinary vegetative leaf. These subtending leaves are bilaterally flattened and closely arranged on the short shoots, with the leaf sheaths imbricate, completely obscuring the internodes of the short shoot (Figure 1A, C). As these subtending leaves are not modified in any way, they are not bracts. The male flowers occur together with the female flowers on the same short shoots, but in the lower, and therefore older leaf axils. The young female flowers are borne singly and totally hidden in the axils of the leaves, and fertile plants can easily be mistaken as sterile. Being more mature, and having larger calyx lobes and protruding stamens, the male flowers are more readily visible than the totally hidden, immature female flowers (Figure 1A, C). This difference in developmental stages between male and female flowers excludes the possibility of self-fertilization.

The fertile short shoot in the axil of a vegetative leaf, on a long shoot, appears to be the inflorescence (Figures 1A; 2A: i1). The presence of vegetative leaves on the short shoot, however, indicates that it is a vegetative shoot. This is confirmed by the lengthening, in ascending order, of the hitherto very short internodes of the short shoot with imbricate leaves, changing it into a long shoot with distant leaves at the time of fruiting. This change clearly reveals the true nature of this short shoot as equivalent to the vegetative long shoots supporting the inflorescences encountered in other species (Figures 1B; 2B).

At the end of the flowering season the male flowers and the fruits are shed and the vegetative stage (Figure 2C) is entered. This is marked by two events. The apical bud of the newly formed vegetative long shoot forms a new apical short shoot (na) and new lateral short shoots (nl) develop in the axils of the leaves which subtended the past season's flowers. Thus longitudinal growth occurred on the main

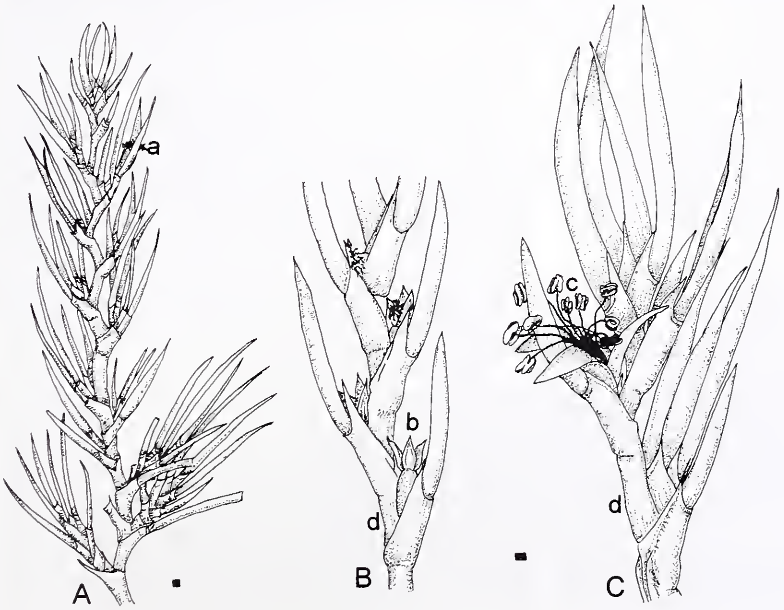

FIGURE 1.—*Cliffortia nivenioides, Viviers & Vlok 470* (BM, K, MO, NBG, P, PRE). A, long shoot bearing short shoots with female flowers in axils of leaves; B, fruit-bearing long shoot, developed out of short shoot; C, short shoot with lower node elongated and lower leaf axil bearing male flower. a, female flower; b, fruit; c, male flower; d, visible internodes. All copied from Inge Oliver's drawings. Scale bar: 1 mm.

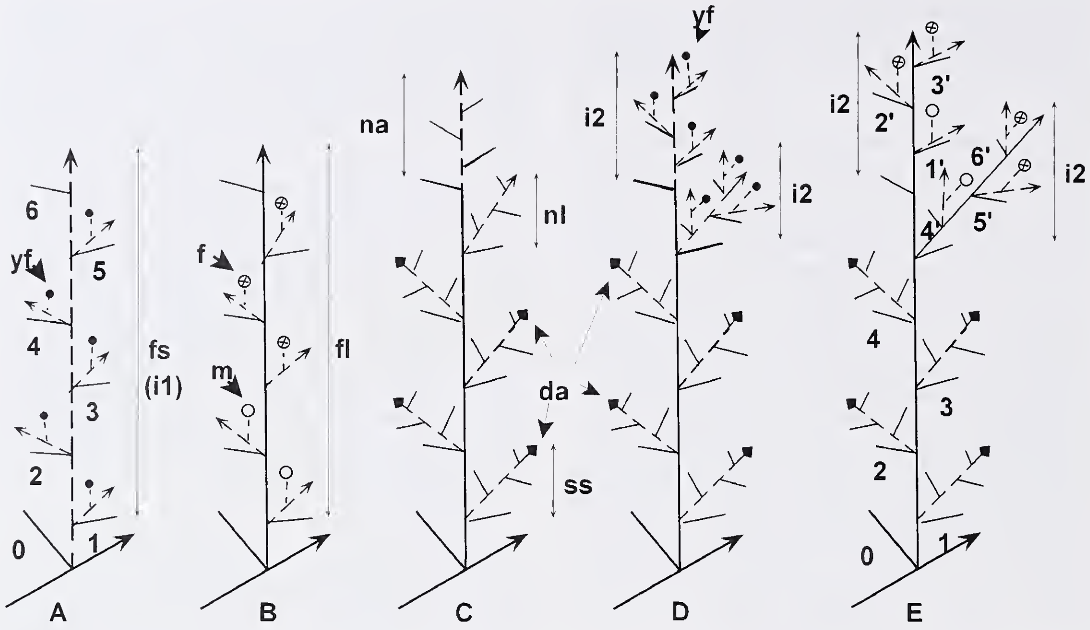

FIGURE 2.—*Cliffortia nivenioides*: longitudinal diagrams of inflorescence and branch development, covering two fertile seasons spanning a vegetative season. A, young fertile short shoot season with young single-flowered inflorescences; B, same as A, matured: a long shoot with mature flowers; C, same as B, vegetative stage: new short shoots developed out of remaining inflorescence; D, same as C, second season: the apical and one lateral short shoot bearing flowers; E, same as D, matured: apical and one lateral long shoot (lateral long shoot to become vegetative branch). O, subtending leaf on main branch; 1–6, subtending leaves of first season's inflorescence; 1'–6', subtending leaves of second season's inflorescences; da, dormant apical buds; f, female flower; fl, flowering long shoot; fs, fertile short shoot; i1, fertile short shoot in A becoming long shoot in B; i2, fertile short shoot in D becoming long shoot in E; m, male flower; na, new apical short shoot; nl, new lateral short shoot; ss, sterile short shoot; yf, young flower. Broken lines: expanded axes of short shoots.

stem and a new branch is formed. The short shoots thus formed, appear to replace the single flowers of the recent flowering season, but are in fact, proliferation shoots of minute, single-flowered inflorescences each with an ebracteate flower. Most of these newly formed, short shoots remain vegetative and do not undergo any further vegetative growth. Their apical buds have become dormant. Only a small number near the apex of the plant develop further, viz. the new apical short shoot (na) and the uppermost new lateral short shoot (nl) and become the new flowering short shoots of the second flowering season (Figure 2D: i2). Their imbricate leaves become the subtending leaves for the new single-flowered inflorescences (Figure 2C–E). As in the previous fertile stage (Figure 2A: fs (i1), B: fl), these fertile short shoot(s) change from short shoots with imbricate leaves, into long shoots with distant leaves as they mature (Figure 2D: i2, E: i2).

The number and positions of the long shoots thus formed, are determined by the number and positions of the short shoots involved in flower bearing. With only the apical short shoot and one lateral involved, the result will be one apical long shoot and one side branch (lateral long shoot) (Figure 2D, E). As before, the next stage of development is the shedding of the flowers leaving the new long shoots with their now no longer imbricate leaves (1'–6'), ready to subtend a new generation of short shoots, some of which are destined to become future branches.

Branching occurs only where lateral long shoots develop. The sparse vegetative branching pattern in this species, is thus directly linked to the structure of the fertile shoot (synflorescence) of the previous fertile season, limiting the development of long shoots. Where only the new apical short shoot (na) develops into the new fertile shoot (i2), no side branch will develop, so that solely longitudinal growth takes place. It is only when one (or more) of the lateral short shoots (nl) are also flower bearing, that one (or more) lateral long shoots develop and branching occurs (Figure 2D, E).

2. *Cliffortia crenata* L.f.

This species occurs on mountain slopes and plateaux at altitudes ranging from 1 300 m in the northern, drier areas of the CFR, to 300 m in the Montagu area. The plants appear to be totally without short shoots, being virgate, lanky shrubs up to 2 m tall, very sparsely branched in the upper parts only. At no time are any flowers visible. The two large leaflets are attached to the stem at an acute angle, completely enveloping it, so that, in order to examine the leaf axils for flowers, at least one of the leaflets has to be folded back or removed.

An immature (primordial) inflorescence (Figures 3G; 4A) consists of a pair of immature flowers, one slightly above the other, attached to a swollen basal structure, with an apical bud between the two flowers. The flowers are subtended by small but unmistakably leafy elements. The size of the immature flowers relative to that of the inflorescence axis, facilitates the interpretation of the structures. It is quite clear that the flowers are borne on the swollen basal structure and not adjacent to it. In terms

FIGURE 3.—*Cliffortia crenata, Oliver 10387* (NBG). A, portion of main branch with condensed inflorescence; B, proliferating inflorescence (branchlet from axil of a vegetative leaf), bearing one male flower and three fruits; C–E, subtending leaves, in ascending order, on branchlet B; F, apical growth point from axil of fourth leaf on branchlet B; G, primordial inflorescence (short shoot from axil of vegetative leaf near apex of a main branch), showing a basal contracted axis bearing two lateral flowers and a central apical growth point. Scale bars: 1 mm.

of the elements of a simple inflorescence consisting of a short shoot, the swollen basal structure is the inflorescence axis bearing two lateral, alternate flowers with the apical portion of the axis continuing beyond. In an inflorescence, condensed to such a degree as this, the subtending leafy elements can be expected to be bracts rather than vegetative leaves.

A primordial inflorescence can develop into one of two types of mature inflorescences: a condensed type or a proliferating type. The condensed type contains a single flower or a cluster of mature flowers, on a much condensed inflorescence axis without any apical proliferation. In a typical instance, three flowers, each laterally in the axil of a bract, are found in a cluster: the two lower female and upper male. These three mature flowers obscure the inflorescence axis and its ancillary vegetative parts viz. leaves or bracts. The two female flowers are much more advanced in development than the male. The one female is a fully developed fruit without calyx lobes, whereas the other is a younger fruit with the calyx still in place. The male flower is still in the bud stage and therefore, much younger than the female flowers (Figures 3A; 4B). In this type of inflorescence there is evidence of the presence of an apical bud but no proliferation takes place. The diminutive size of the subtending leaves suggests that these would not develop into vegetative leaves but rather into bracts, subtending flowers of both sexes.

The proliferating type of mature inflorescence presents not only clusters of fruit and flowers in a more open arrangement than those in the condensed type, but has a viable apical bud which proliferates into a young vegetative shoot, which eventually develops into a branch. The structure that originates in the leaf axil is the shoot and the flowers are borne laterally on the basal part of the shoot and not directly in the axil (Figures 3B; 4C). The lower two flowers are female and close to each other, with their small imbricate subtending modified leaves completely covering the very short internodes. The next slightly more distant flower is female and followed by younger male flower(s). The internodes separating the flowers become increasingly longer upward, but remain much shorter than those higher up on the vegetative part of the shoot (Figure 3B). The leaves subtending the basal female elements (fruits and/or flowers), show progressive development from the base upwards. The lowest are merely scale-like structures, consisting mainly of a narrow sheath without any stipules and with only the vestige of a blade attached directly to the sheath, without articulation (Figure 3C). Above these are leaves in progressive stages of development from very small and bract-like with just the indication of stipules and a single articulating leaf blade (Figure 3D), to almost normal, small vegetative leaves with two leaflets (Figure 3E). These small leaves subtend the male flower in Figure 3B. Above the male flowers, the shoot becomes a normal long shoot with vegetative leaves. In occasional leaf axils near the apices of these vegetative shoots, small buds which could develop into secondary primordial inflorescences, are found (Figures 3F; 4C: pi).

The proliferating inflorescence consists of a basal flower-bearing short shoot (ssh) in which the apical bud proliferates into a distal long shoot (lsh) which will lengthen to extend beyond the subtending leaf on the main stem to form the new branch (Figure 4C). This type of inflorescence occurs less frequently than the contracted type and usually near the apices of the branches. These then, are the only inflorescences that give rise to vegetative branches, as the formation of branches depends entirely on the occurrence of inflorescences with subsequent distal long shoot development. The sparseness of the branching pattern, resulting in the virgate growth form of this species, can thus be directly related to the small number of inflorescences that undergo the full range of changes. The positions of the branches are determined by the position of the proliferating inflorescences which is usually near the apices of existing branches.

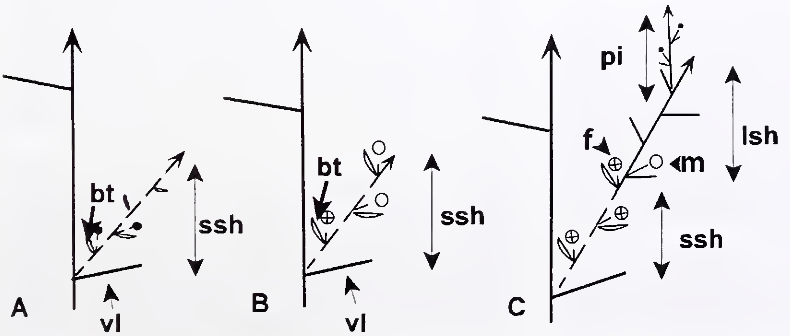

FIGURE 4.—*Cliffortia crenata*: longitudinal diagrams of inflorescences. A, primordial, with immature flowers; B, mature contracted, with mature male and female flowers; C, proliferating, with mature male and female flowers, apical proliferating branch/long shoot (lsh) with secondary primordial inflorescence (pi). bt, bract; f, female flower; m, male flower; ssh, short shoot; vl, vegetative leaf. Broken lines: expanded axes of short shoots.

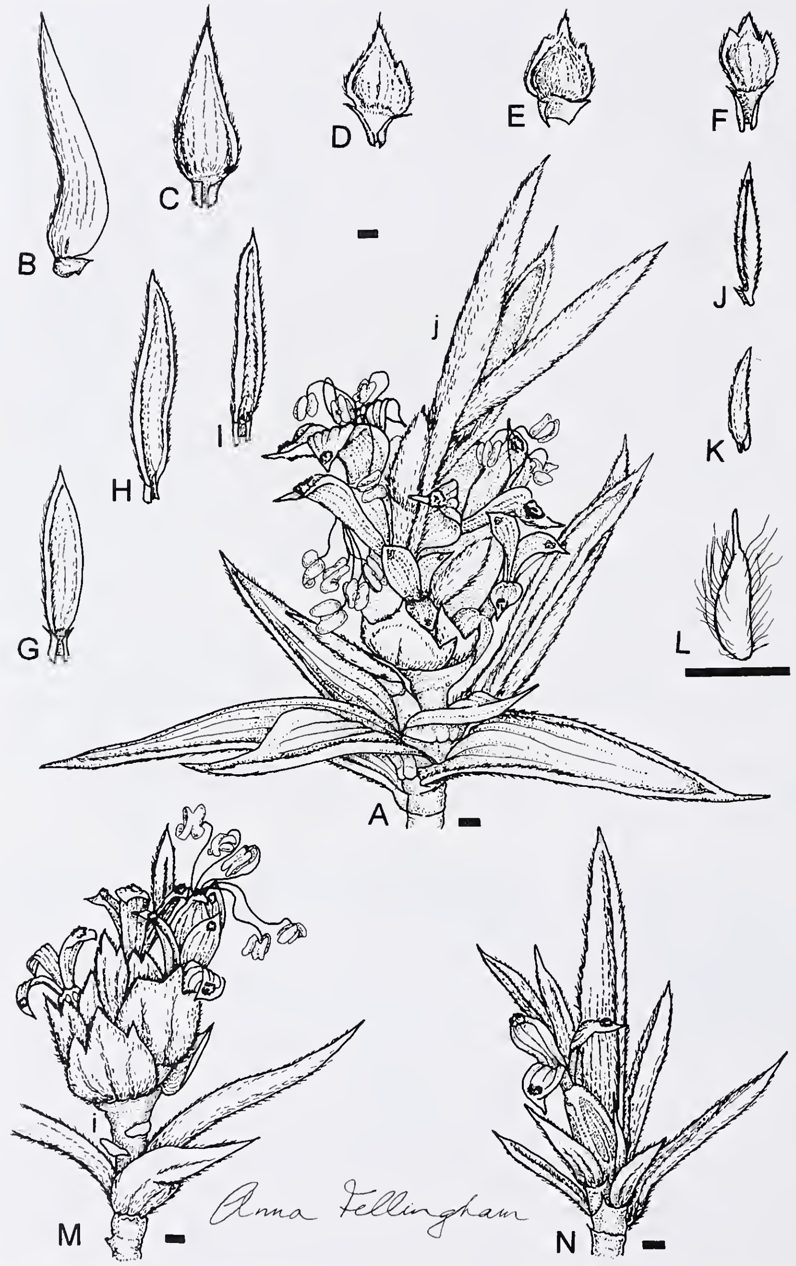

FIGURE 5.—*Cliffortia ruscifolia*. A, well-developed inflorescence exhibiting male and female flowers subtended by tridentate bracts, overtopped by proliferating shoot with linear vegetative leaves; B, C, vegetative leaves from just below inflorescence in A, each successively shorter and broader than the one below; D–F, bracts subtending flowers in inflorescence A; G–K, leaves of proliferation zone in A; L, growth point of proliferating shoot; M, inflorescence with male and female flowers subtended by tridentate bracts and vegetative leaves below inflorescence, shed to form inhibition zone (i); N, rare single-flowered inflorescence (one fruit) subtended by a shortened vegetative leaf (no bract); i, inhibition zone; j, proliferation zone. A–L, *Oliver 10567* (NBG); M, *Oliver 10569* (NBG); N, *Oliver 10574* (NBG). Scale bars: 1 mm.

3. *Cliffortia ruscifolia* L.

This is a widespread and probably the most familiar species of *Cliffortia*, occurring in well-drained habitats over a wide range of altitudes. It occurs in a great variety of vegetative forms from low, sparse, sprawling plants with yellowish green leaves, to erect bushy plants up to 1.5 m tall and with grey-green leaves, from the same locality. The size and shape of the vegetative leaves are also very variable but always unifoliolate and pungent.

The inflorescence is generally bracteose and multi-flowered, rarely single-flowered with the flower apparently subtended by an ordinary vegetative leaf. The latter type could be mistaken for the immature form of the inflorescence if it was not for the fact that the female element in it was a mature fruit. In essence, the inflorescence is a short shoot, occurring in the axil of an ordinary vegetative leaf on a long shoot. Male and female flowers are borne singly in the axils of bracts, in a single inflorescence, usually with the female flowers below the males (Figure 5A, M).

Two distinct zones can be distinguished in the fertile short shoot. The lower zone consists of ± five vegetative leaves, which graduate in form and size from long and narrow (lowest) to much shorter and wider in the highest. All of these leaves are typical vegetative leaves, plain with slightly hairy edges and nerves and sharp apical spinelets. With the leaves diminishing in length upwards,

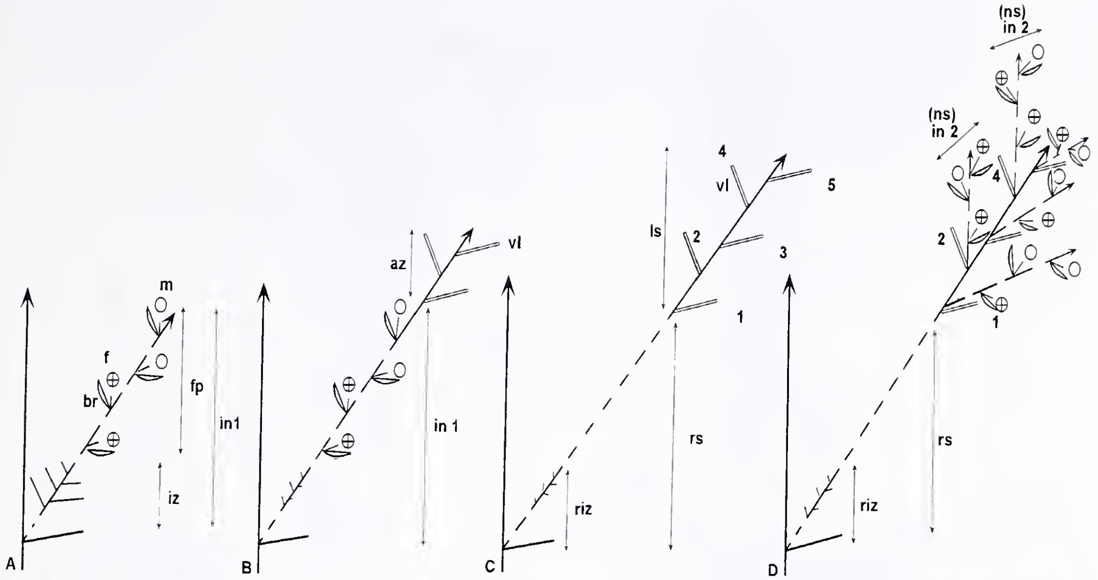

FIGURE 6.—*Cliffortia ruscifolia*: longitudinal diagrams of inflorescence development and related branches. A, young inflorescence in axil of vegetative leaf on long shoot; B, mature inflorescence with proliferation of apical bud; C, vegetative stage: new branch consisting of remains of the short shoot (rs) plus new long shoot (ls); D, new inflorescences in axils of vegetative leaves on long shoot, constituting potential new branches developing as illustrated in B and C. az, apical proliferation zone; br, bract; f, female flower; fp, fertile part of short shoot; in1, inflorescence of first season; in2, inflorescences of second season; iz, inhibition zone; ls, long shoot; m, male flower; ns, new short shoot; riz, remains of inhibition zone; rs, remains of short shoot; vl, vegetative leaf; 1–5, vegetative leaves on long shoot becoming subtending leaves for inflorescences of second season. Broken lines: expanded axes of short shoots.

this zone seems to fit the description for Troll's 'field of inhibition' (Weberling 1989). For such a small area of inhibition as is encountered here, the term inhibition zone seems appropriate. As seen in Figure 5M, the leaves of this area are shed to reveal the fertile part of the inflorescence, a zone of imbricate bracts, each subtending a flower. The bracts are much shorter and more hairy than the leaves of the inhibition zone, and dentate to trilobate. In some instances the apical bracts are immature. All multi-flowered inflorescences contain male and female flowers in equal proportions (Figures 5A–F, M; 6A).

The apical buds of the mature inflorescence proliferate to form comas of young vegetative leaves, some with minute buds in their axils, on a developing long shoot. The appearance of this vegetative long shoot marks the onset of the new vegetative stage. This phenomenon can be defined in terms of Weberling's (1989) concept of 'late proliferation', except that he sets the prerequisite of a frondose inflorescence for the use of this term. It does otherwise fit the requirement of marking the return of the 'inflorescence apex to the vegetative condition'. In spite of the bracteose character of the inflorescence, we propose the use of the term proliferation zone for the early stage of development of the long shoot (Figures 5A, G-K; 6B: az, 6C: ls).

With the appearance of the proliferation zone the vegetative stage is entered. At the same time, or in some instances, before this event, the leaves of the inhibition zone are shed, followed by the shedding of the flowers and their subtending bracts (Figures 5N; 6B, C). The short shoots are thus left bare with the short internodes (which do not elongate) permanently visible. The proliferation zones are thus the entire source of vegetative growth. These then develop into long shoots with proximal zones of bare short internodes, as the only indications of the sites of the old inflorescences. Though these zones are a permanent feature of the basal (proximal) portions of all branches thus derived, they do not contribute any further to their development (Figure 6B–D). As the fertile stage is characterized by the development of short shoots, the vegetative stage is characterized by the development of long shoots proliferating out of the short shoots (Figure 6B, C). Potentially every short shoot could develop into a vegetative branch. Furthermore, all the leaves on a long shoot could become subtending leaves for the next fertile season's short shoots (Figure 6D). However, usually only a limited number of leaves develop short shoots in their axils. Of these short shoots only a limited number give rise to long shoots.

4. *Cliffortia heterophylla* Weim.

This species is locally common in sunny situations near streams in the Betty's Bay area. In the vegetative stage, the plants have the general appearance of saplings up to 3 m tall, with willow-like leaves and some secondary thickening of the main stems. In spring a single conspicuous cylindrical inflorescence develops on the apex of the main stem (Figure 7A). Plants under stress, as those from which the apical inflorescences have been removed or those having their main stems constricted by twiners, may develop multiple lateral inflorescences.

Inflorescences are initially female, then progress through a bisexual phase to the male stage. Only minimal traces of the fertile stage, in the form of amplexicaul

FIGURE 7.—*Cliffortia heterophylla, Fellingham 1640* (NBG). A, female inflorescence on apex of main stem; B, female flower in situ on node (bracts removed); a, bracteoles; b, calyx lobes; h, internode. Scale bar: 1 mm.

sheaths around the main axis of the plant, are left in the vegetative stage, after the shedding of the fugacious bracts (Figure 8: rb). With the secondary thickening of the main stem, these sheaths also disappear as they are stretched and broken.

In the bisexual phase, the inflorescence demonstrates all the different developmental stages in the form of recognizable zones, which are dealt with here in the chronological order of development, viz. female zone, male zone and the two vegetative zones: the inhibition zone and the proliferation zone. The longitudinal diagram (Figure 8) depicts all of these zones as one entity. It is, however, rare to find specimens showing all the stages: usually the proliferation of the apical bud takes place only after the shedding of all sexual elements.

The cylindrical, apical inflorescence is in essence a short shoot up to 240 mm long, the uppermost internodes about 1 mm long, gradually increasing in length to about 7 mm basally. All internodes of the short shoot are totally obscured by the lanceolate-acuminate bracts, which are up to 60 × 15 mm. In the apical part of the inflorescences, the female flowers occur singly on very short asymmetrical structures (Figure 7B). In the older (lower) part of the inflorescence, up to six female flowers are borne on lateral short shoots, totally hidden by the imbricate bracts. (Figure 8: ls). The flowers are lateral on these short shoots, and subtended by leafy elements that are much smaller than, and different in shape to the normal vegetative leaves, and therefore, bracts (bt). The short asymmetrical structures bearing the single flowers higher up on the same inflorescence, can thus be interpreted as primordial short shoots. Such a short shoot has a fully viable apical bud while only the lowest node is mature enough to sustain a fully developed flower, without the bract being in evidence yet. Already at this stage, the inflorescence can be described as a diplobotryum or double raceme, with a central short shoot bearing lateral short shoots in the axils of its bracts; the lateral short shoots bearing (female) flowers in the axils of their bracts.

Two events mark the onset of the development of the male zone. The hitherto short internodes of the apical

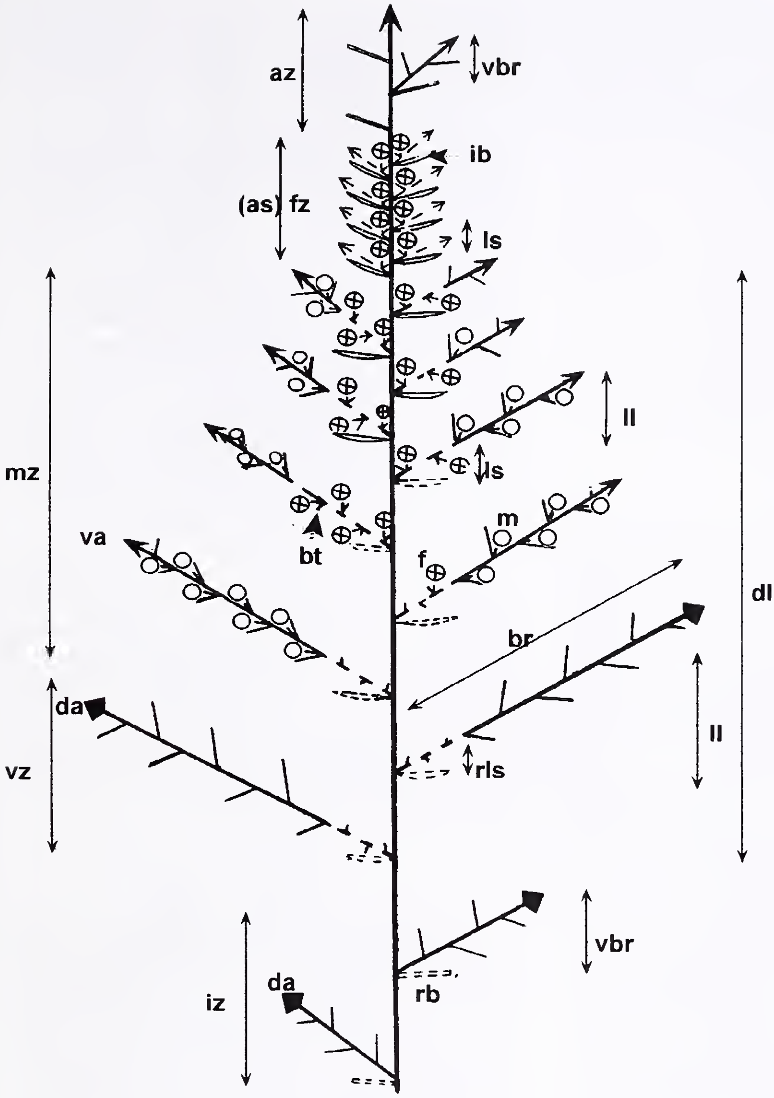

FIGURE 8.—*Cliffortia heterophylla*: longitudinal diagram of inflorescence. as, apical short shoot; az, apical zone; br, branch; bt, bract; da, dormant apical bud; dl, developing main axis long shoot; f, female flower; fz, female zone; ib, imbricate bract; iz, inhibition zone; ll, lateral long shoot; ls, lateral short shoot; m, male single-flowered inflorescence; mz, male zone; rb, remains of imbricate bract; rls, remains of lateral short shoot; va, viable apical bud; vbr, vegetative branch; vz, vegetative zone. Broken lines: expanded axes of short shoots.

short shoot of the main stem start lengthening, the lower ones first and then the others in sequence upwards. The result is the separation of the previously imbricate bracts to reveal the internodes, thus changing the short shoot into a long shoot (Figure 8: mz). At the same time, the apical buds on all lateral short shoots (ls) give rise to long shoots (ll), in sequence from below upwards. These lateral long shoots lengthen and male flowers (m) develop on their distal parts, whereas the female flowers (f) on the proximal part, (short shoot), mature into fruits before dropping off, starting with the lowest, then involving those higher up, again in ascending order (Figure 8: mz).

The formation of the vegetative zone is initiated by the shedding of the male flowers as well as any fruits that might still be present. This leaves the remains of the lateral short shoot (rls) in the form of a region of short internodes, interspersed with ridged nodes, on the proximal part of the branch (br). This is accompanied by the loss of the bracts (ib) on the main stem, leaving their remains (b) in the form of the leaf sheaths which are eventually destroyed by secondary thickening of the main stem. Thus the vegetative zone (vz) comes into being, and develops upwards as the fruit and flowers mature and are shed. With the shedding of the last flower, the vegetative zone spreads to envelop the whole of the inflorescence, reducing it to a framework of newly formed vegetative branches on an apical extention of the original main stem. With this, the vegetative stage has been entered (Figure 8: vz).

The vegetative stage is completed by the development of the apical proliferation zone (az). This is achieved by the proliferation of the apical bud of the main inflorescence axil, which is just a highly condensed portion of the main stem, giving rise to an apical long shoot with vegetative leaves. In the axils of the vegetative leaves of this zone, purely vegetative branches (vbr) develop. These consist of long shoots only, without any remains of lateral short shoots on them as in the case of the branches originating in the inflorescence and are shorter than the side branches originating in the inflorescence (Figure

8: az). The apical proliferation zone thus gives rise to the only purely vegetative growth of the plant. Proliferation of the apical bud can take place early in some instances, producing a coma above the apical cylindrical female zone (Figure 8: az, fz). Normally this occurs only after the vegetative zone is fully developed and the inflorescence has disappeared completely.

The vegetative stage ends when the apical bud produces the new apical cylinder of imbricate bracts, marking the onset of the following fertile stage. This places the old apical proliferation zone directly below the new inflorescence. The youngest (apical) branches of the proliferation zone, will still be relatively short when the new inflorescence starts developing. This can be interpreted as the old apical proliferation zone becoming the inhibition zone of the new inflorescence (Figure 8: iz).

5. *Cliffortia odorata* L.f.

Dense mats of this species occur on the banks of rivers and dams in the southwestern, southern and southeastern coastal districts, usually at low altitudes but also up to 1 000 m on Table Mountain. The upright shrub is up to 2 m tall with the main stems slightly zig-zagging at the nodes, where the branches originate. This irregularity develops as a result of the displacement of the stem by the enlarging highly condensed inflorescences and the subsequent development of the branches in the axils of the amplexicaul leaves at these nodes.

The young inflorescence first appears as a single flower in the axil of a young leaf near the tip of a main stem or branch. This single flower is soon joined on the broad flower base, which is the primordial inflorescence axis, by small clusters of much younger flowers with their bracts and bracteoles developing between the first flower and its bracteoles, thus causing the first flower to appear ebracteate (Figure 9A). These inflorescences are subtended by vegetative leaves, and develop into clusters of flowers of both sexes. Each cluster is composed of several subclusters, each subtended by a bract-like, highly modified and extended membranous leaf sheath without a leaf blade. The individual flowers are interspersed with membranous bracts in varying states of development, with an occasional ebracteate flower. The subclusters are implanted onto a flattened disc, the condensed inflorescence axis, by means of short stalks. Removal of the subclusters reveals the discreet implantation sites left on the disc. In the centre of an occasional inflorescence in this stage of development, a small raised area in the shape of a pyramid occurs. This pyramid is the apical bud of the condensed inflorescence axis, starting to proliferate (Figures 9E; 10A).

In a significant proportion of inflorescences, further changes follow, culminating in production of a central branch in each inflorescence. In some cases, the central pyramidal section of the initially much-condensed inflorescence axis, develops into a very short vegetative shoot with one or two of the subclusters attached to it, thus separating these subclusters somewhat from the rest of the inflorescence. At the same time, vegetative leaf blades develop on the sheaths subtending the subclusters, thus marking the nodes in the condensed inflorescence axis more clearly (Figures 9C; 10B). This interspersing of partial inflorescences with vegetative shoots, results in the formation of a branch complete with small lateral inflorescences. (Figures 9B; 10C).

More often though, the inflorescence remains tightly compact when the apical bud proliferates above the subclusters, generating a new branch. The amplexicaul sheath of the vegetative leaf on the main stem, subtending this compact inflorescence with its central branch, becomes much extended (Figure 9D). In large mature inflorescences with the central branch well developed, the implantation sites of the subclusters are so numerous as to be closely packed around the base of the branch, in a distinctly spiraling pattern (Figure 9F). This compact inflorescence with the apical proliferation, giving rise to a branch, represents the basic structure of the typical inflorescence. It exhibits a clear distinction between the production of short shoots, or as in this species, a system of short shoots, associated with the fertile stage and the long shoot formation of the vegetative stage (Figure 10A).

With two highly modified short shoots viz. the primary inflorescence axis as a flattened disc and the secondary axis as the stalk to a subcluster of flowers, the inflorescence can be defined as a double raceme or a diplobotryum. The arrangement of these subclusters (diplobotrya) within the total inflorescence is, however, not a fixed state. As seen above, in the instance of vegetative shoots and leaves developing in the inflorescence, a certain degree of plasticity exists, allowing the initially compact inflorescence to become more open (Figures 9C; 10B).

6. *Cliffortia arborea* Marloth

For a considerable time this species was the only known ‘tree’ in the genus. Marloth (1905) noted the height as occasionally up to 10 m. There was considerable variability in growth form and sexuality in the studied population in the Nuweveld Mountains above Beaufort West. On terraces against rock ledges about 100 m away from the sheer cliffs, the growth form was that of upright trees up to 4 m tall, with main trunks up to 150 mm in diameter and with reddish brown, flaking bark, and mostly female cones. On the edge of the cliffs, the population was smaller and the growth form more stunted and compact, and the plants were almost totally covered in male flowers from just below the occasional apical female cones to the lowest branches brushing the ground.

Female cones appear as apical thickenings on the ends of main branches. On older plants, the female inflorescence cones can be clearly seen to occur in series, from the older ones below to the one of the current season above (Figure 11A). Occasionally cones are also found on side branches originating from older cones lower down on main branches (Figure 12A).

The female inflorescence forms an oblong cone-like polytelic synflorescence (Figure 12A, B: SN) consisting of an aggregated and spirally arranged condensed lateral double racemes (homothetic diplobotrya). In the young (current season’s) cone, each diplobotryum culminates in a coma of vegetative leaves forming a star-shaped rosette. Together, the rosettes cover the cone in a shroud

FIGURE 9.—*Cliffortia odorata*, *Fellingham 1660* (NBG). A, young, apparently single-flowered, inflorescence with central female flower and two lateral clusters of immature flowers in axils of its bracteoles; B, main stem with three well-developed vegetative leaves, each subtending a discrete inflorescence containing flowers of both sexes; C, proximal side of inflorescence with two pairs of subclusters separated by short vegetative shoot; D, main stem with compact inflorescence of three clusters (flowers and bracts removed, leaving subtending leaf sheaths) enveloping base of side branch originating within uppermost leaf sheath; E, semischematic drawing of young condensed inflorescence axis in leaf axil on main stem with three implantation sites of flower clusters and central raised pyramid marking onset of branch proliferation; F, mature form of E with well-developed central branch surrounded by numerous spirally arranged implantation sites of flower clusters. Scale bars: 1 mm.

of neatly arranged stars, from which the common name for this species viz. *sterboom* (= star tree) is derived.

On the main axis of the cone, trifoliolate primary cone leaves with broadened curved sheaths with or without pungent stipules, are spirally arranged (Figures 11B; 12B: pcl). Each primary cone leaf subtends and surrounds a diplobotryum (DB). A diplobotryum consists of a number of co-florescences (CoF) on a secondary axis, which is basally much condensed but apically proliferates into a vegetative shoot, bearing the star-like coma of vegetative leaves. The co-florescences (botrya) are arranged on the basal condensed part of the axis and surrounded by involucre-like groups of unifoliolate secondary cone leaves (scl), which form the firm part of the cone underneath the shroud of comas (Figures 11C; 12B:

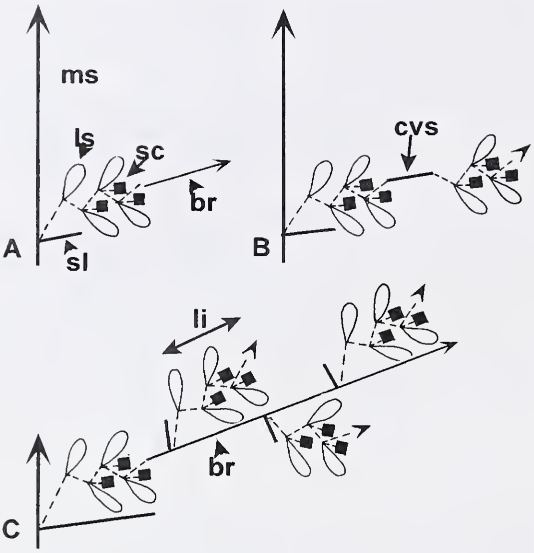

FIGURE 10.—*Cliffortia odorata*: longitudinal diagrams of inflorescences in different stages of development. A, compact mature inflorescence with apical branch; B, open inflorescence separated into two parts by central vegetative short shoot; C, later developmental stage with three lateral inflorescences. br, branch; cvs, central vegetative short shoot; li, lateral inflorescence; ls, leaf sheath subtending subcluster; ms, main stem; sc, subcluster; sl, subtending leaf. Broken lines: considerably expanded axes of short shoots.

scl). The botrya (co-florescences) are highly condensed with the axes not more than a slightly raised flattened area bearing a number of tiny flowers in a capitulum-like arrangement. The flowers are almost completely hidden by the secondary cone leaves with not much more than the strap-shaped styles and stigmas showing.

Mature cones proliferate apically into a vegetative continuation of the main axis, which will give rise to the following season's cone. Furthermore, the star-like comas of vegetative leaves marking the apices of the diplobotrya, proliferate into vegetative side branches. These can bear female cones, male flowers or eventually thicken and continue the vegetative development of the plant (Figures 11A; 12A: VB). Old cones are retained on main stems for a number of years but eventually disintegrate. This happens in stages. Firstly, after three or four years, abscission of the secondary cone leaves takes place at the top of the sheaths, leaving the woody bases on the main branches for several years (Figure 11A). Eventually the clusters of secondary leaf bases get separated from each other, as the main branches bearing them undergo longitudinal growth and secondary thickening. By that time, the leaf bases will have been reduced to a few scattered scales on the main stem and will be hardly recognizable as the remains of the original cone.

Male inflorescences are simple clusters of a few ebracteate flowers in the axils of vegetative leaves on lateral branches. These are borne below the female cones but on the same main branches (e.g. *Acocks 18625, Fellingham 1625, Marloth 9730*). Occasionally male flowers also occur on the thin side branches originating from older female cones (*Fellingham 1625*), but always lower down on the plant than the female inflorescences of the same season. While distinctly monoecious, this species never has the male and female flowers occurring in the same inflorescence. Where male flowers do occur on the thin vegetative side branches of the occasional older female cones, as seen in *Fellingham 1625*, they are more than a year younger than these female cones and borne on vegetative shoots, and not on the female cones themselves.

7. *Cliffortia dichotoma* Fellingham

This new species of *Cliffortia* section *Arboreae*, from near Nieuwoudtville, Namaqualand, is closely related to *C. arborea*. It occurs on rocky ledges, on slight northern and southern slopes on the Oorlogskloof escarpment, south of the Oorlogskloof Nature Reserve. The whole population is old and moribund, with part of every plant dead and dry. No seedlings have been found for at least 25 years.

The plants appear more tree-like than any other species in the genus and are up to 5 m tall. The main trunks are buttressed and therefore irregular in shape, up to 500 × 300 mm in cross section, and bare for the lower 0.5 m. Branching is dichotomous from below a cone, with the new season's cones at the tips of the new branches (Figure 14A). This branching pattern results in a tree with a spreading canopy.

In spring female cones are initiated as swellings covered by imbricate, hard, spiky, tridentate leaves with broad, amplexicaul sheaths, at the tips of some of the branches (Figure 13A). By early summer these are fully developed young female cones with numerous circles of long, maroon, strap-shaped stigmas marking rosettes of conical, hairy and pointed modified leaves, the centres of which soon become raised and punctuated by 'stars' of about 5 vegetative leaves. The two lateral branches directly below the cone, start to thicken and curve upward in preparation for the production of the following season's pair of apical cones (Figure 13C). By the following spring the old female inflorescence cones are shrouded in numerous upwardly curving vegetative branchlets, having originated from the 'stars' of the previous spring, plus one apical, straight and slightly more robust, branchlet. The two branches just below the cone are close together and clearly more robust than the ones lower down (Figure 13B).

The female inflorescence cones consist of a number of lateral condensed double racemes (homothetic diplobotrya) (Figure 14B: DB), each consisting of a few sessile capitulum-like co-florescences (botrya) (CoF). These are aggregated and spirally arranged on a condensed main axis to form an oblong, cone-like, polytelic synflorescence on the end of a main branch, originating as one of a pair from below a cone of the previous season (Figures13C; 14A–D). Each diplobotryum is subtended by a primary cone leaf (pcl) with a grossly extended sheath segregating the individual diplobotrya from each other, and a tridentate, often stipulate, woody blade just emerging between the involucres of secondary cone leaves (Figures 13E; 14B–D). The secondary cone leaves have thickened woody sheaths without stipules and swollen trifoliolate blades, with the leaflets of each

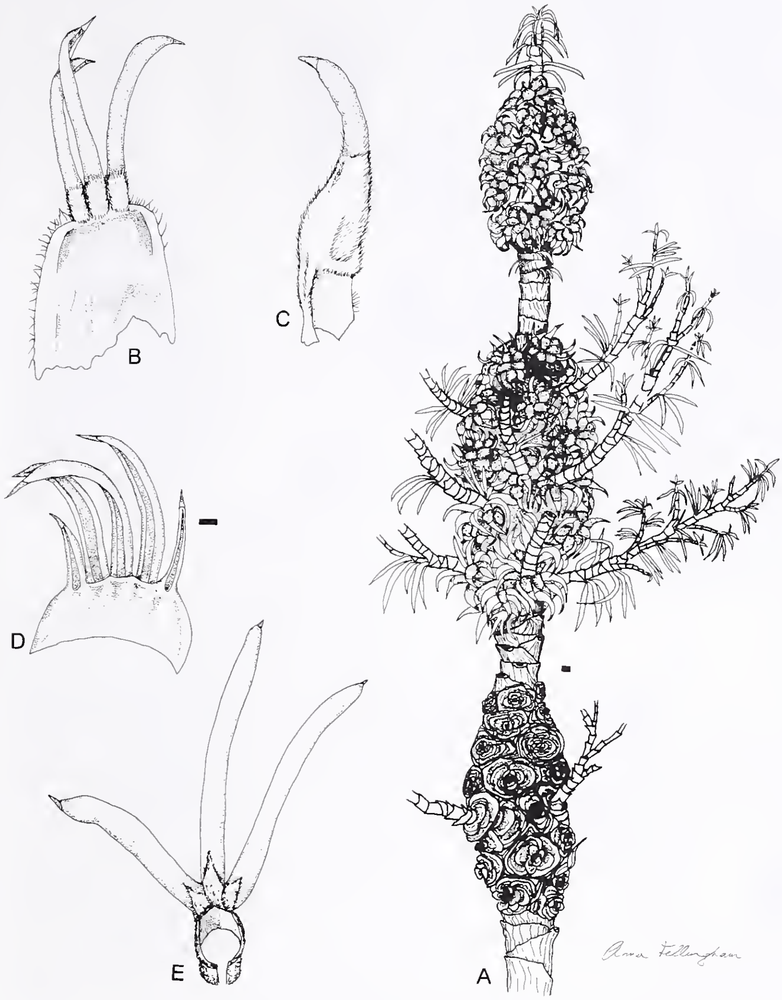

FIGURE 11.—*Cliffortia arborea*. A, apical portion of main stem with three female inflorescences (cones) in situ, oldest one lowest, weathered to basal portions of primary and secondary cone leaves and the remains of two lateral branches; B, primary cone leaf, astipulate type, adaxial view; C, secondary cone leaf, lateral-adaxial view; D, leaf from region of stem directly below female cone, abaxial view; E, vegetative leaf, adaxial view. A, *Fellingham 1624*; B–E, *Oliver 10054*. Scale bars: 1 mm.

leaf arranged in triangles (Figures 13D; 14B, C, D: scl). Both the primary and secondary cone leaves differ from the ordinary vegetative leaves, which are small, unifoliolate and ligulate in shape (Figure 13G). Each secondary cone leaf subtends a capitulum-like botrys, bearing up to 12 flowers on minute pedicels, subtended by greatly modified bracts (Figure 13F). The flowers, each with three or four calyx lobes, are totally hidden amongst the secondary cone leaves with only their ligulate styles protruding (Figure 13C). The fully developed fruits are irregularly angular and closely packed in the concavity in the adaxial side of the sheath of the secondary cone leaf, which subtends the capitulum-like flower-bearing structure, the co-florescence (Figure 13D). In the mature young cone in which proliferation of the apical bud has already given rise to a conspicuous vegetative continuation of the main stem, spirally arranged circles of long maroon stigmas—each circle with a tridentate, woody, primary leaf below it—demarcate the double racemes (diplobotrya) (Figure 13C).

In the slightly more mature cone with withered stigmas, the centres of these circles are raised as the second order axes proliferate, and each circle becomes crowned with a star-like arrangement of vegetative leaves. The appearance of the 'stars' that are to develop into the shroud of side shoots, seems to coincide with fertilization, as at that point the styles begin to dry and shrivel. As the second order axes elongate in the more mature cone, the 'stars' are replaced by a shroud of vegetative side shoots (Figure 13B). These side shoots as well as the apical proliferation of the main stem, are shed in the older cones. It seems that the shrouds of shoots are in place during the development of the fruits, which is the rest of the current season and the following one.

The male inflorescences are in the axils of ordinary vegetative leaves on branchlets lower down on the main branches bearing the female cones, and consist of solitary male flowers or small groups of very shortly pedicelate male flowers with much reduced bracteoles (Figure 13G).

8. *Cliffortia conifera* E.G.H.Oliv. & Fellingham

The only known population of this species is on an east-facing cliff edge, on the Anysberg. The small group of tree-like shrubs up to 4 m tall and with the main trunks up to 150 mm in diameter, resemble conifers in their upright growth form, as well as in their cone-like inflorescences, each terminally on a short lateral branchlet.

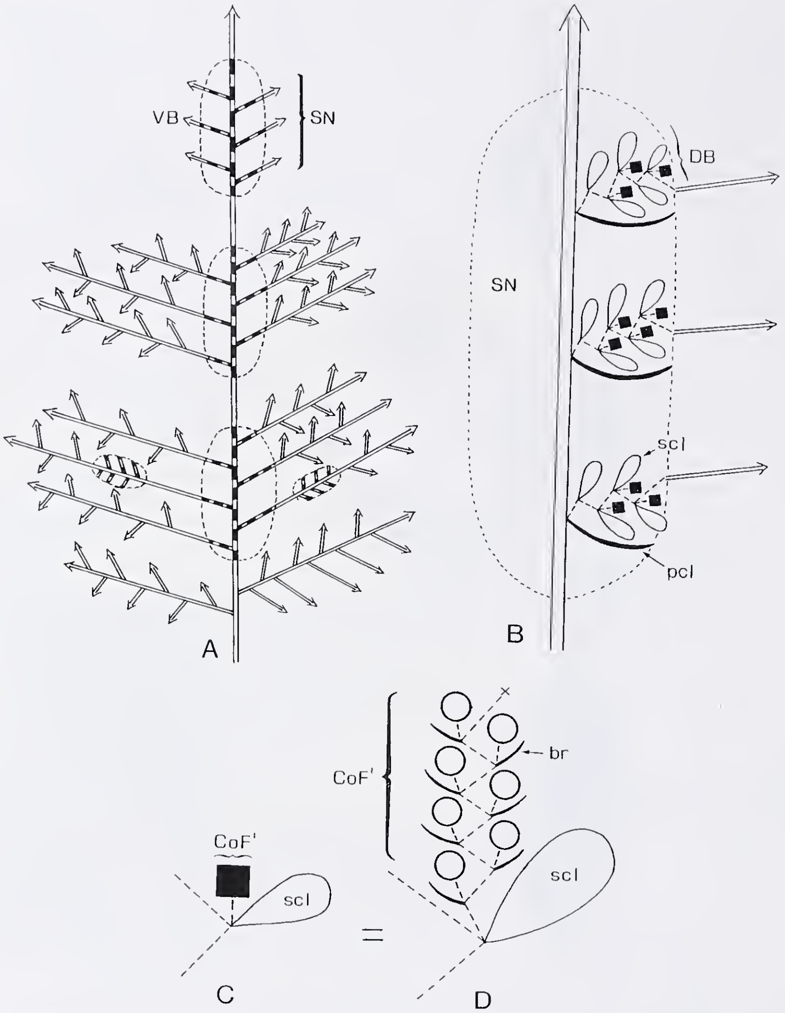

FIGURE 12.—*Cliffortia arborea*: longitudinal diagrams of inflorescences. A, three female cones on main branch and two on lateral branches; B, part of cone showing three dibotrya with vegetative branches; C, D, single botryum or co-florescence (solid square), expanded to show individual flowers (circles). br, bract of single flower; CoF, co-florescence or botryum; DB, diplobotryum; pcl, primary cone leaf; scl, secondary cone leaf; SN, synfloresense; VB, vegetative secondary branch. Broken lines: considerably expanded axes of short shoots.

These cone-bearing branchlets occur in groups of up to 10, in subterminal zones on main branches; rarely on secondary branches. Older branches have several zones of cones interspersed with vegetative regions consisting of well-developed, leaf-bearing lateral branches.

The obovoid or occasionally spheroid female cone consists of many condensed double racemes (homothetic diplobotrya) aggregated on a shortened main axis, which is the condensed end of a lateral branchlet. The cone is devoid of proliferating shoots, either from the ends of the double racemes or the apex of the cone (Figures 15A; 16A, B). The cone can be interpreted as a polytelic synflorescence composed of numerous (up to 50), condensed, sessile racemes (botrya), the co-florescences, grouped together in highly condensed, double racemes (diplobotrya). The co-florescences resemble capitula with up to 16 flowers all arising at the same level from the truncated end of the very short, 3rd order, florescence axis. The flowers are interspersed with long erect hairs from which the variously modified and reduced bracts just emerge. Except for the protruding stigmas and occasionally the small calyx lobes, the flowers (and eventualy the fruit) are concealed by the bulbous secondary cone leaves on the 2nd order cone axes, which are involucrally arranged and form the matrix of the cone. The secondary cone leaves are unifoliolate, lack both stipules and sheaths but have a demarcation between the upper bulbous part with velvety indumentum, and the basal flattened glabrous part (Figures 15C, D; 16B: scl). The primary cone leaves originate on the main cone axis, subtend the lateral second order diplobotrya and are also concealed by the secondary cone leaves. The primary cone leaves differ from the secondary cone leaves in having extended leaf sheaths with stipules and, being uni- or trifoliolate (Figures 15E; 16B: pcl). Both the primary and secondary cone leaves differ from the ordinary vegetative leaves which are trifoliolate, the leaflets flat with rolled edges and plain to tridentate and the sheath amplexicaul and stipulate (Figure 15A, B).

The male inflorescence is a much simpler structure, consisting of a cluster of 3 or 4, occasionally 5 flowers, on a highly reduced short shoot, in the axil of a subapical vegetative leaf, on lower lateral branches, well below zones of female cones (Figure 15B).

DISCUSSION

Although only eight species of the 119 in *Cliffortia* were included in this study, they are representative of the

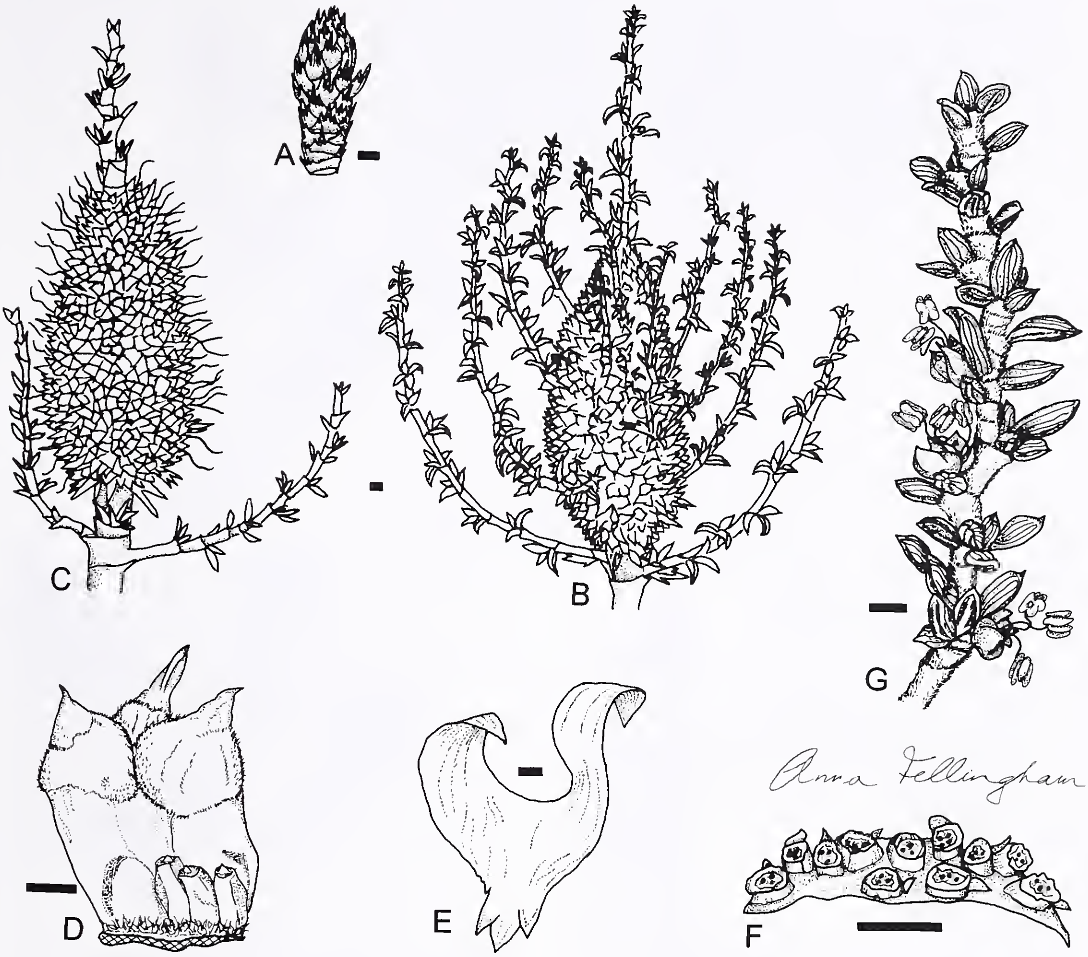

FIGURE 13.—*Cliffortia dichotoma*. A, apical swelling on main stem; B, mature inflorescence cone shrouded in vegetative lateral branchlets and apical continuation of main stem; C, young female inflorescence cone with numerous circles of strap-shaped stigmas; D, secondary trifoliolate cone leaf with exstipulate wooden sheath, subtending capitulum-like botrys bearing three remaining fruits; E, primary cone leaf with extended curved sheath; F, capitulum-like botrys, flowers and surrounding hairs removed exposing pedicels, each with subtending modified bract; G, vegetative branch with male flowers. A, B, D, F, *Fellingham 1684* (BOL, NBG); C, E, G, *Fellingham 1689* (BOL, NBG). Scale bars: 1 mm.

types of inflorescences in the genus, covering the range from the single-flowered inflorescence in *C. nivenioides*, to the highly condensed and discrete female cone in *C. conifera*. There is no hypothesis of the phylogenetic relationships in *Cliffortia*, so our sampling could not be based on the phylogenetic patterns in the genus. Nonetheless, it seems likely that the sampling captured most of the variation in the inflorescence morphology in the genus.

Basic inflorescence construction

The basic inflorescence unit in *Cliffortia* is a short shoot with one or more internodes, bearing one or several lateral, unisexual flowers, which may be bracteate or ebracteate. This is therefore an indefinite polytelic florescence (Weberling 1989). The short shoot itself is borne in the axil of a vegetative leaf. In its most common form, the shoot is single-flowered, and this misled Weimarck (1934) into interpreting them as 'solitary flowers in the axils of ordinary vegetative leaves'. There are a number of ways in which this can be modified to generate the diversity of inflorescences observed in *Cliffortia*: these are detailed below.

Given that all inflorescences are basically racemose short shoots, there are a number of parameters that vary among species in the genus, and that are to some extent responsible for the variability in the inflorescence constructions:

1, number of flowers per inflorescence. These vary from one (probably the most common situation in the genus), to several as in *C. ruscifolia*, to numerous as in *C. heterophylla, C. odorata* and the three coniferous species of the section *Arboreae*. In some cases, initially only one or a few flowers are formed (usually female). When these flowers have matured, growth resumes in the florescence, to form a further set of usually male flowers. In *C. heterophylla*, though, the female florescence continues growth as a long shoot, which then bears single-flowered lateral male florescences;

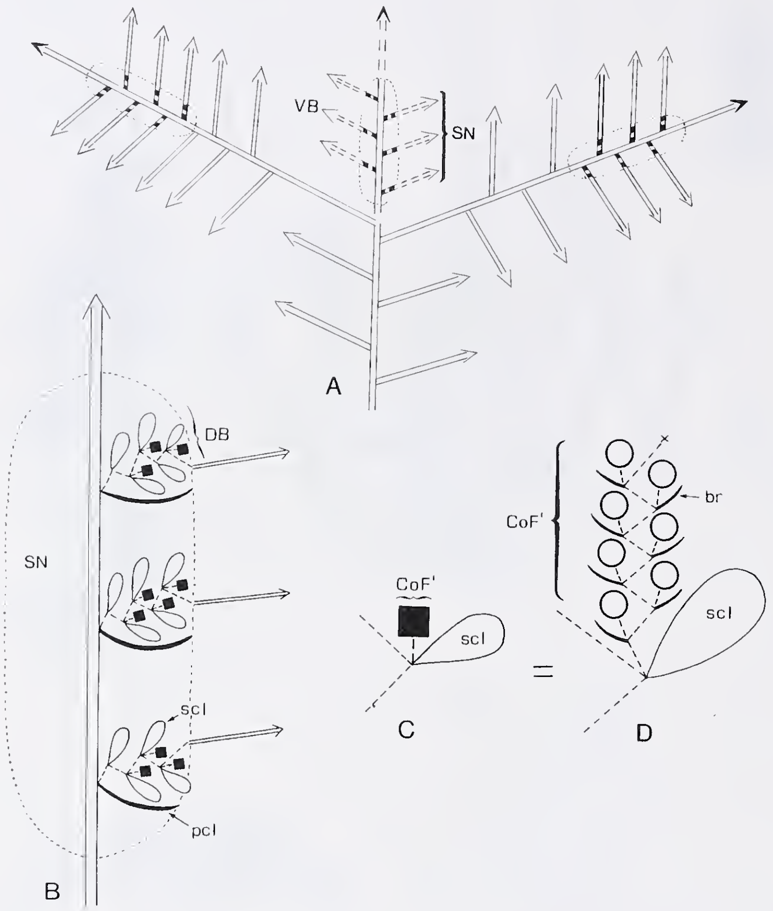

FIGURE 14.—*Cliffortia dichotoma*: longitudinal diagrams of inflorescences. A, three female cones, two on dichotomous branches, central one older, having lost its apical and lateral branches; B, part of cone showing three dibotrya with vegetative branches; C, D, single botryum or co-florescence (solid square), expanded to show individual flowers (open circles). br, bract of single flower CoF, co-florescence or botryum; DB, diplobotryum; pcl, primary cone leaf; scl, secondary cone leaf; SN, synflorescence; VB, vegetative secondary branches. Broken lines: considerably expanded axes of short shoots.

2, the short shoot internodes are generally about equal in length. This is so in most primary short shoots, secondary short shoots and even in systems containing tertiary short shoots as well. In *C. odorata*, however, the axis of the primary short shoot is very condensed, forming a flattened disc borne in the axil of a vegetative leaf. This disc-like short shoot retains its viable apical bud and bears secondary short shoots in the form of stalked discs as the ultimate flower-bearing short shoots. Disc-like ultimate flower-bearing short shoots also occur in *C. arborea, C. conifera* and *C. dichotoma*, but in these species as the tertiary short shoots;

3, aggregation of short shoots can be variously developed. In some cases, the florescences are borne solitary, although generally in distinct zones on the plant. However, they may be aggregated into clusters (in *C. odorata*), elongated synflorescences (in *C. heterophylla*), or aggregated into dense cone-like structures (in *C. arborea, C. dichotoma* and *C. conifera*). Some of these synflorescences can be remarkably complex, and diverse in structure, while exhibiting great plasticity;

4, short shoots transforming into long shoots. After the flowers on the short shoot have matured, the internodes elongate, thus transforming the short shoot into a long shoot, as seen in *C. nivenioides* and *C. heterophylla;*

5, viability of the apical bud of short shoot. In *C. conifera* all apical buds of short shoots have lost their viability. In the other species, continued growth from at least some of these apical buds variously affects the synflorescence, and often the whole plant architecture. Firstly, continuing the growth of the florescence generally leads to the bearing of a later generation of male flowers after the initial generation of female flowers. This was observed in a number of species, such as *C. crenata, C. heterophylla* and *C. odorata*. This extends the period of time over which the florescence unit remains productive, and allows for the evolution of herkogamy at an inflorescence (rather than flower) level. Secondly, this continued growth may lead to the formation of new vegetative shoots, thus true proliferation, where the reproductive apical bud transforms to a sterile (vegetative) bud. This is common in the genus, and is discussed in more detail below.

The approach of searching for a basic pattern in the inflorescence, and then establishing how the inflorescence can be modified to produce a remarkable diversity of apparently different types, can be very productive. Weber (1995) used this approach to show that in *Phyllagathis* superficial description of inflorescences can be quite misleading, and that this can be revealed by searching for the basic pattern (in this case a monotelic homocladic thyrse). Here we attempt to account for the variation in inflorescences in *Cliffortia* by finding ‘switches’, simple ‘on or off’ devices. Modifications in the behaviour of the apical buds of the inflorescences,

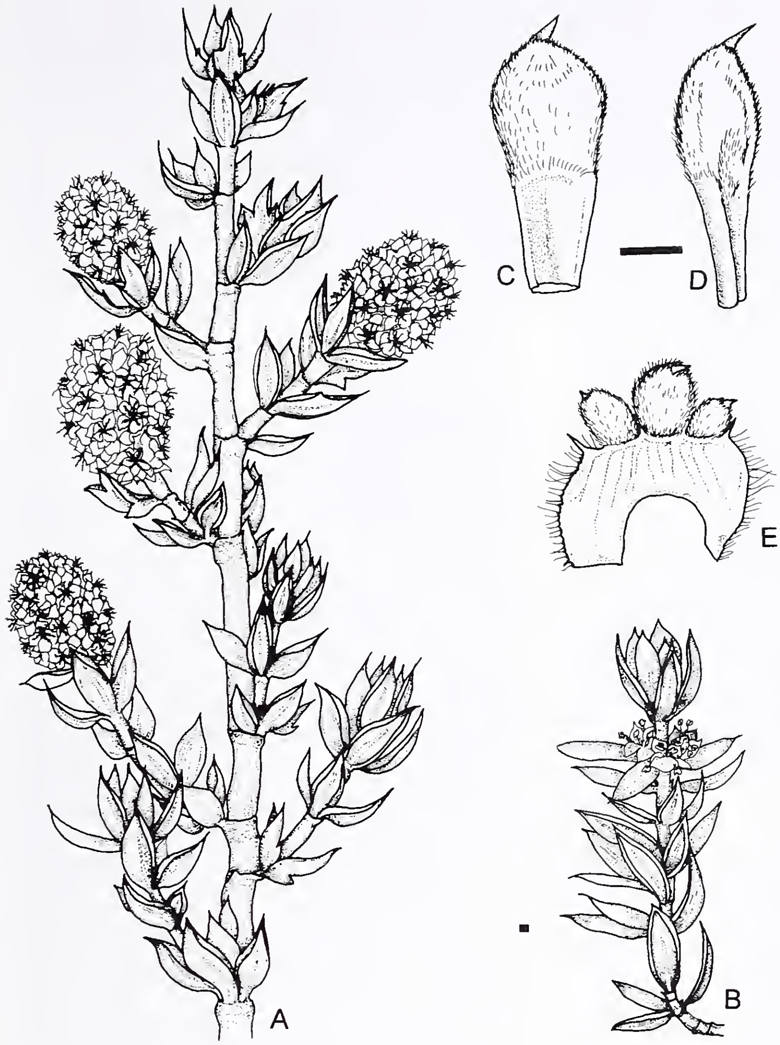

FIGURE 15.—*Cliffortia conifera, Oliver 10055* (NBG). A, branch bearing female cones; B, branchlet bearing male flowers. C, D, secondary cone leaf: C, adaxial view; D, lateral view. E, primary cone leaf, adaxial view. A, B, copied from Inge Oliver's drawings. Scale bar: 1 mm.

and the timing of internode elongation of the synflorescence and florescence axes, should be adequate. Such modifications have also been used to explain the variation in the inflorescences of the legume tribes Ingeae and Acacieae (Grimes 1999). These 'switches' could then be used as characters for a cladistic analysis. This could lead to a much better set of inflorescence homologies, than using descriptive terms directly, since using the switches allows for more intermediate conditions.

The possible characters that could be used are listed below. We have not attempted to score these for the species, since our sample of species is too small to be able to interpret the result: 1, florescence number of flowers: one/several; 2, florescence flower arrangement: protogynous/mixed; 3, florescence growth: continuous (all flowers formed more or less at the same time)/ interrupted (leading to sex changes); 4, florescence short shoot: permanent/later elongating into long shoots; 5, florescence apical bud: terminating/proliferating; 6, synflorescence apical bud: terminating/proliferating; 7, florescences: solitary/aggregated/forming cones; 8, male and female florescences: in the same synflorescence/in separate synflorescences.

Sexuality

The flowers are always unisexual, and there are several ways in which the male and female flowers can be combined to form a monoecious species. The following three patterns were observed:

Firstly, the male and female flowers may be found in separate synflorescences, and would therefore be spatially separated. This is exemplified by the cone-bearing species, *C. arborea, C. dichotoma* and *C. conifera*, in which the female florescences are many-flowered and are aggregated into cone-like synflorescences which are completely female. Male florescences are borne in separate, very different looking synflorescences with very few flowers. This situation is comparable to that found in most conifers.

Secondly, single-flowered florescences where the male and female florescences are combined into a common synflorescence. The only species with this pattern investigated is *C. nivenioides*. Male florescences mature first, followed by a time lag before the females mature.

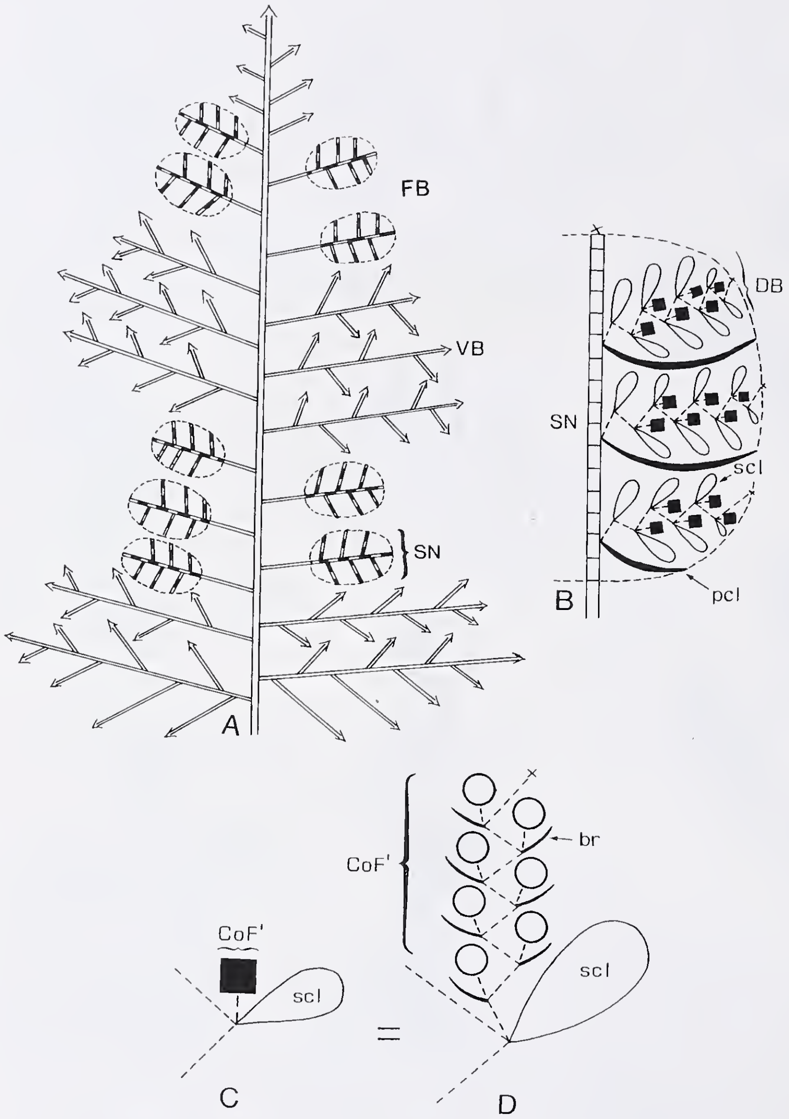

FIGURE 16.—*Cliffortia conifera*: longitudinal diagrams of inflorescences. A, main branch with two cone-bearing zones; B, part of female cone showing three dibotrya; C, D, single botryum or co-florescence, (solid square) expanded to show individual flowers (circles). br, bract of single flower; CoF', co-florescence or botryum; DB, diplobotryum; FB, flowering secondary branches; pcl, primary cone leaf; scl, secondary cone leaf; SN, synflorescence; VB, vegetative secondary branches. Broken lines: considerably expanded axes of short shoots.

Thirdly, male and female flowers are found in the same florescence (raceme), the flowers are separated usually with the female flowers borne below the male flowers (thus on the older parts). In general, the females then flower before the males, so that there is no overlap in the flowering time between male and female flowers. Thus the inflorescences are dichogamous. This has been referred to as sex changes or sequential hermaphrodism of the individual (Freeman *et al.* 1980), and is particularly well illustrated by *C. heterophylla*. The individual always starts out as overtly female, then becomes bisexual, and eventually is overtly male. Single observations would suggest that the species is dioecious, and bisexual individuals could be taken to be anomalous. This sequential hermaphrodism is only possible because of the morphological plasticity of the inflorescences, and in particular because the apical buds retain viability. Sex changing (or sequential hermaphroditism) as 'a phenomenon of at least some dioecious species', has more recently been based on findings in 66 species in 25 families, documented from as early as 1910 (Freeman *et al.* 1980). 'Apparent dioecy' in any one season, masking the true labile nature of the sex of the plant which can change with changes in the physiological state, which in turn depends on external factors, was described in *Arisaema triphyllum* (Araceae) by Bierzychudek (1982). She also found that all *Arisaema* species change sex, though only some change from male to female without any hermaphrodites. Similar findings of sex changes were reported in *Myrica gale* (Myricaceae) (Proctor *et al.* 1996).

Two of the species investigated here have bisexual florescences, but show no segregation of the sexes either in time or space. In *C. ruscifolia* the female flowers were in the fruit stage when the males still had good anthers [*Oliver 10387* (NBG)]. The same phenomenon is seen in *C. odorata* [*Fellingham 1664* (BOL), *1678* (BOL)].

It appears as if all species of *Cliffortia* may be monoecious. Previously it had been suggested that the standard condition in *Cliffortia* is that the plants are dioecious, and Weimarck (1934) suggested that ± 60% of the species in the genus are 'capable of being monoecious'. This could be a misinterpretation based on single samples of species exhibiting sex changes, such as *C. heterophylla*. Oliver & Fellingham (1991) described *C. burgersii* as dioecious, but this might reflect yet another example of the possible erroneous interpretations of morphologically different stages of a monoecious plant, as morphologically different plants of a dioecious species. It seems essential to follow a plant through its flowering sequence to uncover sequential female and male phases.

Wind pollination

Many of the specializations in the inflorescences of *Cliffortia* can be interpreted as adaptations to wind pollination. The genus as a whole shows typical wind-pollinated flowers: a reduced, dull perianth, and unisexual flowers (Faegri & Van der Pijl 1979; Proctor *et al.* 1996; Linder 1998). Since most species and genera in the Sanguisorbae are wind pollinated, the anemophilous syndrome was mostly inherited by *Cliffortia*, and indeed many of the typical wind-pollination features of *Cliffortia* are also found in the related genera *Acaena, Sanguisorba*, and others. Wind pollination is generally seen as a common alternative to biotic pollination in species-poor or cool habitats where the survival of biotic pollinators would be difficult (Whitehead 1969, 1983). Yet, wind pollination has frequently evolved in the species-rich and structurally dense Fynbos of the Cape Floral Kingdom, and is found in the Ericaceae, Proteaceae, Asteraceae (*Tarchonanthus*), Rubiaceae (*Anthochortus*) and Rosaceae (*Cliffortia*) (Koutnik 1987; Le Maitre & Midgley 1992). Accepted as a primitive condition in the gymnosperms, it had been confirmed in the Cape genera *Podocarpus* and *Widdringtonia* (Koutnik 1987). Within *Cliffortia*, most inflorescences appear to separate male and female flowers either in time (through sequential hermaphroditism) or spatially (in the species with cones, where female and male synflorescences are separated). However, the coniferous species of *Cliffortia* have a rare reversal of the location on the plant of the male and female elements, with the male below the female. This rare condition is shared with only one evergreen gymnosperm, viz. *Pinus sylvestris* (Proctor *et al.* 1996).

Impact on vegetative branching

In *Cliffortia* the florescences generally proliferate, that is, the apical bud transforms to a vegetative bud, and growth continues into the next season as a vegetative shoot. This can be a major source of vegetative branching to the plant, and as such have a major impact on the plant architecture. The degree of involvement of the various orders of short shoots, determines the abundance and positions of long shoots produced.

A sparsely branched, lanky growth form is produced where flower bearing is limited to a few apical vegetative short shoots. These are the only short shoots that eventually develop into long shoots (vegetative branches) by the lengthening of their internodes (e.g. *C. nivenioides*). By contrast, the rich and random branching pattern in *C. ruscifolia* originates from its numerous inflorescences. Most of these proliferate into vegetative long shoots. A sparse and virgate branching pattern results from the small percentage of inflorescences, all near the apex of the main stem, that proliferate. This is seen in *C. crenata*. The monopodial branching in *C. odorata* is the result of proliferation of the primary short shoots of numerous axillary inflorescences on main stems, which themselves grow vegetatively only. The monopodial branching of *C. heterophylla*, however, is the result of a combination of two factors. The fast-growing main stem gains from the lengthening of the primary short shoot of the apical inflorescence as well as the eventual apical proliferation. The limited linear increase in the lateral branches, originating from the proliferation of the second order short shoots, enhances this effect. Similarly, in the young plant of *C. arborea*, the monopodial branching is regulated by the proliferation of the first order short shoot, which is the main stem of the plant. As the plant ages and side branches become involved in flower bearing, the branching pattern is obscured. A peculiar involvement of the position of the inflorescence determining the branching pattern is found in *C. dichotoma*. With the abortion of all initial proliferation shoots, two vegetative branches, close to each other and just below the terminal inflorescence, take over the function of continuing linear growth. These develop into a pair of thick main branches, one on each side of the central apical inflorescence. This results in the dichotomous branching pattern, unique in the genus. It is only in *C. conifera*, the species that exhibits no morphological plasticity of the inflorescence, that there is no effect of the inflorescence on the branching pattern, other than that a zone of branches are dedicated exclusively to the bearing of the female cones. In this aspect, it approaches the condition in the gymnosperms.

In inflorescences consisting of a system of short shoots of primary and secondary or primary, secondary and tertiary short shoots, it is always only the ultimate short shoots that are dedicated to flower bearing, to the extent to which the viability of their apical buds is lost. The apical buds of the lower order short shoots, forming the matrix of the inflorescence, however, retain their viability. These are the short shoots that can undergo one of two changes, or a combination of these two, at the onset of the vegetative stage or, in some instances, during the development of the inflorescence. The changes to the short shoot are the lengthening of the internodes rendering it a long shoot, or the proliferation of the apical bud into an apical long shoot, or a combination of the two processes. With the lengthening of the internodes, it becomes a long shoot without leaving a trace of the original short shoot. With the addition of apical proliferation to the lengthened shoot, the ensuing long shoot would gain greatly in longitudinal growth. It is only in the case of apical proliferation without any lengthening of the internodes, that the original short shoot can still be discerned. It is this inherent morphological plasticity of the matrix of the inflorescence that renders it capable of contributing to the vegetative growth both in substance and pattern.

SPECIMENS EXAMINED

Fresh material

Notes

1. Fresh specimens of *Cliffortia heterophylla* (4): *Karin Behr sub Fellingham 1638*; *Jane Forrester sub Fellingham 1640* (4) NBG, BOL,

were examined in the early Spring of 1994. Six field trips were undertaken between the 3-01-1995 and the 22-06-1995 to the Harold Porter Nature Reserve in Betty's Bay, to study this species in situ. Sketches are from *Forrester sub Fellingham 1640* (4) NBG, BOL.

2. Field work was done on the two populations of *C. arborea* (6) on the Nieuweveldberg escarpment, at Beaufort West and fresh material taken for study were *Fellingham 1624* female (6) MO, NBG, PRE; *1625* male & female (6) BM, NBG, PRE.

3. Field work on *C. dichotoma* (7) was done in September 1995, November 1995, November 1996, and October 1997, on the Farm Papkuilsfontein in the Lokenberg area of Namaqualand. Specimens were collected on all of these occasions. The fresh specimens studied and sketched were *Fellingham 1684* (7) BOL, K, NBG, PRE and *Fellingham 1689* (7) BOL, K, NBG, collected on 27-09-1995 and 16-11-1995 respectively.

4. Fresh material of the type specimen of *C. conifera* (8), *Oliver 10055* male & female (8) BOL, K, NBG, PRE, was examined and sketched. The type locality, the eastern end of the Anysberg in the Ladismith District, was visited and more fresh material, *Fellingham 1531* female (8) NBG, collected for examination in the herbarium.

Other fresh material

Fellingham 1647–1652, 1654–1658, 1663, 1668, 1673, 1675, 1677 (4) NBG; *1660, 1664, 1678* (5) NBG; *1662, 1674, 1676* (4) BOL. *Fellingham & Vlok 1588* (1) NBG.

Oliver 10387 (2) NBG; *10567, 10569, 10574* (3) NBG.

Viviers & Vlok 470 (1) NBG.

Herbarium specimens

Acocks 18621 male & female (6) BOL; male & female (6) K; male (6) NBG; *19280* (2) NBG.

Barker 5593 (3) BOL; *8263* (2) NBG. *Barnes s.n.* (3) BOL. *Bean & Trinder-Smith 2733* (2) BOL. *Bolus 2754* (2) NBG, *7600* (2) BOL, NBG; *10603, 12674* (3) BOL; *19854, 19855* (5) BOL. *Bond 1754* (1) NBG, PRE. *W.Bond 1511* (2) BOL. *Boucher 209* (4) NBG, PRE; *502* (3) NBG, PRE; *4193, 5019* (2) NBG. *Burman 895* (3) BOL.

Compton 3039, 9492 (3) BOL; *3040, 3459, 3920* (2) BOL, *5685, 7412, 8662, 10830, 11831, 18425, 18523, 22216, 22247, 22843* (2) NBG; *14374, 51589* (5) BOL. *Cooper 1451* (5) BOL.

De Villiers s.n. immature female (6) NBG. *De Vos 624, 1213* (4) NBG. *Dickin 83* (5) BOL. *Durand 263* (3) NBG, PRE.

Ebersohn 15/68 (4) NBG. *Ecklon & Zeyher 1720* (3) BOL. *Esterhuysen 3447, 5139, 5263a, 10346, 13959, 25911, 27596* (2) BOL; *5241a* (2) NBG; *s.n., 3030, 3443, 9540, 29097* (3) BOL; *13677* (4) BOL; *29003* (4) BOL, NBG; *1831, 15311, 19430, 23890, 29064, 30049, 33509, 33759* (5) BOL.

Fellingham 1533 (2) NBG; *1702* male & female (7) BOL, NBG, male (7) PRE, K; *1705, 1709* (7) BOL, NBG, PRE; *1706, 1707, 1708, 1710, 1711, 1712* (7) BOL. *Fourcade 24* (5) BOL; *3089* (3) BOL.

Gillett 1908 (2) BOL, NBG; *4244* (3) BOL. *Goldblatt 2162* (2) NBG. *Grobler 20181* (4) NBG.

Haynes 362 (3) NBG, PRE. *Hennecart 54* (3) BOL. *Hugo 911* (2) NBG. *Hutchinson 1123* (2) BOL.

Kerfoot 5397 (3) NBG, PRE. *Kruger 801* (4) NBG; *1204, 1346* (2) NBG, PRE.

Leighton 12 (3) BOL; *13* (4) BOL; *2977* (5) BOL. *Levyns 482, 2918, 3016, 4061, 4091, 4776, 7938, 8056, 9141, 11634* (3) BOL; *2051, 2460, 6167, 6444, 6511, 8010, 8975, 9210, 11194* (2) BOL; *6466* (5) BOL; *7789, 7795, 8095* (4) BOL; *Lewis 6065* (2) NBG. *Loubser 825* (5) BOL.

Maguire 155 (3) BOL. *Manson 130* (3) NBG, PRE. *Marloth 1977* (2) NBG, *9089* (2) BOL; *3907* female (6) BOL, male (6) K; *9730* male & female (6) NBG; *9770* female (6) NBG, PRE; *14106* (4) NBG; *Mauve, Van Wyk & Pare 28* (2) NBG. *McDonald 1688, 1732* (2) NBG. *McOwan STEU13375* (2) NBG. *Michell BOL16091* (5) BOL. *Moffett & Steensma 4067* male (6) NBG.

Nel & Boucher 73 (5) BOL, K, NBG, PRE.

Oliver 4252, s.n. (2) NBG; *9730* female (8) NBG, PRE, S; *10054* female (6) BOL, K, MO, NBG, PRE, S.

Parker 3663 (5) BOL; *3717* (3) BOL. *Paterson 2015* (5) BOL. *Pillans s.n.* (2) BOL; *7358, 9292* (3) BOL. *Pretorius 396* (7) BOL, K, MO, NBG, PRE.

Rehmann 2716 (2) BOL. *Rodin 3091* (3) BOL.

Salter 6335 (2) BOL. *Schoncken 269* (2) NBG. *Shearing 893* female (6) PRE. *Simpson 93* (2) NBG. *Sims 2514* (5) BOL. *Stephens 7125* (3) BOL. *Stokoe 405* (4) BOL, PRE, SAM; *7260* (3) BOL; *7264, 9048, 17238* (4) BOL; *SAM61486, SAM59988* (4) NBG, SAM; *s.n.* (5) BOL.

Taylor 4728, 8023, 9517 (2) NBG. *Thode 4818* (2) NBG. *Thompson 176* (3) NBG, PRE; *2275* (1) NBG, PRE. *Tyson 766* (2) BOL, NBG.

Van der Merwe 847 (4) NBG. *Van Niekerk 763* (2) BOL; *787* (3) BOL. *Van Wilgen 162* (3) NBG, PRE. *Van Wyk 536* (2) NBG; *1072* female (8) NBG. *Yvette Van Wyk 626* (7) NBG. *Van Zyl 3363* (2) NBG. *Vlok 1326* (1) NBG, PRE. *Von Willard s.n.* (7) NBG.

Walters 1741 (2) NBG. *Whitman s.n.* (3) BOL. *Wolley Dod 5* (3) BOL. *Wurts 1366* (2) BOL, NBG.

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More accurate publication dates for H.C. Andrews' *The Heathery*, particularly volumes 5 and 6

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Keywords: dates of publication, *Erica* L.

ABSTRACT

Using three types of evidence—dated watermarks; dates of flowering of *Erica* L. species in cultivation in England; dates on which Andrews prepared the original drawings—it is concluded that the six volumes of Henry Charles Andrews' *The Heathery* were published as follows: volume 1, not earlier than June 1805; volume 2, not earlier than 1806; volume 3, 1806; volume 4, 1807; volume 5, not before 1816; volume 6, late in 1828. Consequently, most, if not all, of Andrews' new names for *Erica* species were first published in *Coloured engravings of heaths*.

INTRODUCTION

Henry Charles Andrews published *The Heathery* as a convenient, working edition of his lavish, large-format part-work *Coloured engravings of heaths*. When completed, *The Heathery* comprised six volumes, each containing 50 hand-coloured plates with accompanying brief text, and an alphabetical index numbering the plates. The introductory pages were essentially similar to those in *Coloured engravings* but the text was revised according to experience. Inevitably, the 'Introduction' (in vol. 1) was quite different and solely an explanation of the new work; it contained a statement that *The Heathery* would be published in parts (as all Andrews' other publications had been) and that 'when one volume is completed, every necessary requisite for binding will be given'. However, it is our contention that this was not the case, and that the individual volumes of *The Heathery* were published as separate, complete volumes. There is no evidence known to us in the form of wrappers or partial sets of unbound parts that *The Heathery* were issued, like *Coloured engravings of heaths*, in sequential fascicles for later collation and binding.

As with *Coloured engravings of heaths*, which has been discussed in detail by Cleevely & Oliver (2002), the dates of issue of *The Heathery*, especially the last two volumes, are problematic. The title pages of the six volumes are dated as follows: 1, 1804; 2, 1804; 3, 1806; 4, 1807; 5, 1809; 6, 1804 (for comment on the title page of the last volume, see below). Hitherto, taxonomists (e.g. Dulfer 1965) have accepted those dates as the correct publication dates, except for that of vol. 6; for the sixth volume, 1812 has been the date generally cited in botanical monographs following Pritzel (1872). Kerkham (1988) gave 1804–1809 as the date range for publication of the six volumes of *The Heathery* but also remarked that 'Vol. 6 must have been published much later as there are 1826 watermarks in it.' Stafleu & Mennega (1992) accounted for only the first four volumes stating the dates from the title pages.

At present, we have been unable to discover how *The Heathery* was advertised, sold or distributed. We have not been able to trace any published references to it in contemporary periodicals.

In this paper we present evidence supporting Kerkham's (1988) remarks and contradicting the title page dates for vols 1, 2, 5 and 6. We conclude that those dates are far too early, and in particular that instead of publication of vols 5 and 6 of *The Heathery* preceding publication of *Coloured engravings of heaths*, those two volumes, like the previous four, were published after the relevant fascicles of *Coloured engravings of heaths*.

We have examined the sets of *The Heathery* held in the following libraries and a private collection; data extracted from these copies are held by the authors on a database: 1, Lindley Library, Royal Horticultural Society, London (complete); 2, The Linnean Society of London (partial set, vols 1–3); 3, Royal Botanic Gardens, Kew (partial set, vols 1–3, parts of vols 4 and 5); 4, Bolus Herbarium, University of Cape Town (cited as BOL by Kerkham (1988)) (complete); 5, Compton Herbarium, National Botanical Institute, Kirstenbosch (formerly in Cape Government Herbarium) (complete); 6, Molteno Library, National Botanical Institute, Kirstenbosch (partial set, vols 1–3); 7, South African National Library (formerly called South African Library), Cape Town (cited as SAL by Kerkham (1988)) (complete); 8, Walter J. Middelmann, Rondebosch, Cape Town (complete).

It is surprising that so few complete copies seem to exist, and the occurrence of incomplete sets of the plates, especially from the later volumes, might indicate that these could be obtained separately, or even in fascicles, although, as noted, we do not consider this to be the case. Alternatively, it might be that the volumes really were heavily used as 'working' tools—Andrews described *The Heathery* as a 'green-house companion'—and suffered accordingly.

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THE HEATHERY: PLATES

The plates published in *The Heathery* are directly related to the plates in *Coloured engraving of heaths*. Comparison of the individual illustrations indicates that *The Heathery* plates, which, as noted below, are invariably dated *after* the companion ones in *Coloured engravings of heaths*, show only a small portion of the plant as portrayed in the main work. Many, but not all, *The Heathery* illustrations are reversed and in some instances alterations are evident. The enlarged dissections, arrayed along the bottom of each plate in *The Heathery* are also either mirror images or redrawn or new. The redrawn dissections sometimes differ in details—broader appendages, filaments omitted, or the ovary now included in the small gynoecium/androecium dissection—and in most of these cases the whole drawing is redone with the anthers in different positions and with a different aspect. Reversed images corroborate evidence of the engraved publication dates that Andrews prepared new plates for *The Heathery*, often, but not always, using the printed plates from *Coloured engraving of heaths* as the templates. Had he used his original drawings as templates for the engravings published in both books, the images would all have had the same orientation.

Regarding engraved dates on botanical illustrations published in Great Britain during the eighteenth and nineteenth centuries, under an Act of Parliament (8 George II.c.13) passed in 1734, authors of an engraved work were granted copyright protection 'to commence from the day of the first publishing thereof, which shall be truly engraved with the name of the proprietor on each plate, and printed on every such print or prints' (see Henrey 1975: II, p. 664; Stearn 1940). Thus the legally required engraved date *should* be the exact date of publication. However, by the early nineteenth century, although this act and several subsequent ones were still in force, authors, including Andrews, began to abandon the practise of engraving dates on their illustrations, probably because the necessarily lengthy process of production of these hand-coloured illustrations meant that engraved dates were not the true dates of publication.

THE HEATHERY: VOLUMES 1–4

It is generally accepted that the first four volumes of *The Heathery* are not of nomenclatural significance. While the dates on the title pages are not always consistent with the contents, amending the dates of publication of these volumes will not cause shifts in the priority of names.

Volume 1 has a title page dated 1804, but according to the dates engraved on the 50 plates, almost two-thirds (29) of the plates were not prepared until 1805. The latest engraved date is June 1805 (*Erica walkeria*: t. 50). It should be noted that with a single exception, all the engraved dates in this volume post-date those on the corresponding plates in *Coloured engravings of heaths*. The one exception is the plate depicting *Erica pubescens minima* which is dated May 1805 in *The Heathery* (t. 39) but 1 June 1805 in *Coloured engravings of heaths* (vol. 2: t. 124).

The watermarks in copies of this volume are confusing. While the dates 1804 and 1805 predominate in the copies we have examined, it is clear from paper dated 1808, 1810, 1812 and 1822 that both plates and text pages were reprinted on more than one occasion, probably as customers requested copies or back numbers.

We conclude that contrary to the date on the title page, vol. 1 was issued not earlier than June 1805.

Volume 2 has a title page dated 1804, but according to the engraved dates this could not have been issued before 1806. Forty-two plates are dated 1805, six are dated 1806. Without exception, all the engraved dates coincide with or post-date those on the corresponding plates in *Coloured engravings of heaths*. Watermark dates range between 1803 and 1805, although one text page with 1808 has been noted.

We conclude that contrary to the date on the title page, vol. 2 was issued not earlier than 1806.

Volume 3 has a title page dated 1806 and 36 plates are also so dated. Two plates are dated 1805 but none is dated 1807. As with vol. 2, all the engraved dates coincide with or post-date those on the corresponding plates in *Coloured engravings of heaths*. We have not detected any anachronistic watermarks in this volume; the dates that can be determined are 1803, 1804 and 1805.

It is probable that this volume was completed in 1806, and as it would be odd if it was published before vol. 2, the two could have been issued together.

Volume 4 has a title page dated 1807. Five plates are dated 1806 and 26 are dated 1807. One 1809 watermark date has been detected but could indicate a reprinting of that plate (*Erica canaliculata minor*: t. 157). As with vols 2 and 3 all the engraved dates coincide with or post-date those on the corresponding plates in *Coloured engravings of heaths*.

These suggest that vol. 4 was completed and perhaps published in 1807.

In a catalogue issued in 1813, Andrews stated that he had 'finished his various botanical works' and sought 'to remind ... his Patrons' that they 'may now complete their sets'—*Coloured engravings of heaths* was stated to comprise three volumes and *The Heathery* just four volumes (Andrews 1813: [i]). Judging by Andrews' phraseology, he deemed these works complete. Thus it seems that publication of volume 5 of *The Heathery* and volume 4 of *Coloured engravings of heaths* had not been commenced in 1813.

THE HEATHERY: VOLUMES 5 AND 6

The evidence for much later dates than those stated for vols 5 ('1809') and 6 ('1804') is three-fold; first, dated watermarks [as noted by Kerkham (1988)]; second, the dates when the portrayed heathers flowered in England; third, the dates on which the original drawings were stated to have been prepared by Andrews.

As far as we can ascertain, the sixth volume did not have a separate, new title page. For some unknown reason, Andrews re-used the title page of volume 1 but had it modified by hand, the Roman numeral 'V' being neatly inserted before the original numeral 'I'. Thereby the volume number was amended from one to six, whereas the date '1804' remained unaltered. He followed the same procedure with vol. 4 of *Coloured engravings of heaths*, re-using the title page of the first volume and inserting by hand the Roman numeral 'V' after the 'I' (see Cleevely & Oliver 2002: 249).

Watermarks

When using watermarks to date publications, several points have to be borne in mind. Despite the requirements of the Paper Act of 1794 that enabled paper manufacturers to qualify for exemption from the payment of Excise Duty on any paper produced for export, they were not meticulous in changing the date used in their moulds. The date 1794, in particular, occurs in many publications printed between that year and 1801. Secondly, in a study of dated papers, Heywood (1950) concluded that the average interval between the making of a paper and its actual use was a little under three years.

Although virtually all the watermarks found in *The Heathery* are of Whatman papers, these were made at two different mills and by two separate businesses. The watermark 'J. WHATMAN' was retained by William Balston when he sold the premises of Turkey Mill to the Hollingworth Brothers in 1806, on the dissolution of the partnership he had had with them since 1794. The name of the mill was added to the Whatman name in order that it could continue to be used by the Hollingworths from 1807.

Balston briefly used 'WRB' upon opening his new Springfield Mill (one of the first to rely on steam power) in 1807. After 1814, he adopted various other designations with the Whatman mark which reflected the management of the new business. These included 'J. Whatman & W. Balston' and later 'J. Whatman & W. Balston & Co.', followed, after 1822 when his son joined him, by 'W. Balston & Son' (Balston 1954).

The occurrence of the dated watermarks 'W. B]alston & Co. 1815' and 'Balston 1815' in copies of *The Heathery*, apart from the date itself, support the thesis that the publication date of vol. 5 cannot be earlier than 1816. It has been claimed by Balston (1954: 124) that 'there is only one known instance of a Balston watermark after 1816', although other examples in that work and our current examination refute this.

As already noted, Kerkham (1988) remarked that 'vol. 6 must have been published much later as there are 1826 watermarks in it.' However, it must be kept in mind that we have detected watermark dates as late as 1822 in vol. 1, so we urge treating the watermark evidence with circumspection.

The following is a summary of the watermark evidence: Volume 5: in the examined copies, we have detected six plates with dated watermarks for 1812, eight text pages and two plates with 1815, and one text page and two plates dated 1816; Volume 6: in the examined copies, we have detected the following dates: 1824 (four: one plate; three text pages); 1825 (five plates); 1826 (ten; two plates; eight text pages); 1828 (one plate).

Dates of raising and flowering

All the plants portrayed in *The Heathery* and in *Coloured engraving of heaths* were cultivated in English gardens, and Andrews proclaimed on the title page of *Coloured engraving of heaths* (1802: vol. 1) that 'the drawings [were] taken from living plants only.' Given this, the dates of raising and of flowering are clearly of importance in determining dates of publication because, put simply, a plant could not be included in any illustrated work until it had been raised in an English garden or nursery and grown until it bloomed. This is especially significant when it is recognized that many of the heathers included in vols 5 and 6 of *The Heathery* were horticultural variants, sometimes artificial hybrids, produced in England. Some plants were even unique, known to Andrews only from a single individual.

There is however one difficulty with Andrews' dates, as demonstrated by this example. Regarding *E. beaumontia*, Andrews stated that 'This fine new species of *Erica* was raised from Cape seed last Autumn, 1827, and flowered the ensuing summer for the first time at the Nursery of Messrs Rollisson, Lower Tooting ...'. To raise seedlings of any heather and get them to bloom within nine months, which is the approximate interval between 'late Autumn 1827' and the 'ensuing summer', is impossible. Even with modern glasshouse facilities the minimum time from seedlings appearing to flowering is ± three years. Thus Andrews' dates of raising are suspect, although he may only have reported the information that Messrs Rollisson gave him. As for flowering dates, there is no apparent reason to doubt their accuracy because only plants that had bloomed are illustrated.

The dates that Andrews gave in vol. 4 of *Coloured engraving of heaths* for plants which he also featured in vol. 5 of *The Heathery* and which post-date its stated year of publication, 1809, are summarized in Table 1. For vol. 6, only those which post-date 1819 are summarized.

TABLE 1.—Dates of *Erica* plants featured in vols 5 and 6 of *The Heathery*

Vol. 5	
dumosa (t. 213)	raised 1815
sulphurea (t. 241)	raised 1814
Vol. 6	
bauera (t. 252)	bloomed autumn 1823
beaumontia (t. 253)	raised 1827; bloomed 1828
costata superba (t. 256)	raised 1820
droseroides minor (t. 259)	raised autumn 1820
minutaeflora (t. 270)	raised 1822
ruber-calyx (t. 285)	raised 1825
russeliana (t. 286)	raised summer 1824
suaveolens (t. 292)	raised 1828
templea (t. 293)	raised about 1820
tenuiflora carnea (t. 294)	raised 1824
vernix rubra (t. 298)	raised 1823, bloomed spring 1824
viridiflora (t. 299)	first observed 1820

Those dates alone are sufficient to point to publication dates not earlier than 1815 for vol. 5, and not before 1828 for vol. 6.

Drawing dates

Given the relationship between the plates in *Coloured engravings of heaths* and *The Heathery* when Andrews gave a date for the illustration in the former (Table 2), it can be argued that this date must also apply to *The Heathery.* Andrews dated the following illustrations (see Cleevely & Oliver 2002).

TABLE 2.—Dates of *Erica* illustrations in *Coloured engravings of heaths* and *The Heathery*

Vol. 5	
argentiflora (t. 202)	1814
praestans (t. 231)	June 1810
regerminans (t. 235)	1810
splendens (t. 240)	1816
taxifolia major (t. 243)	1809
thunbergia (t. 244)	October 1815
Vol. 6	
cruciformis (t. 258)	1819
exsurgens hybrida (t. 261)	autumn 1824
foliacea (t. 263)	summer 1822
glomerata (t. 264)	1818
imperialis (t. 266)	November 1818
lawsonia (t. 267)	summer 1818
mirabilis (t. 271)	summer 1824
nivalis (t. 274)	May 1820
peltata (t. 276)	1823
pellucida rubra (t. 277)	1816
quadrangularis (t. 280)	1819
radiata discolor (t. 281)	autumn 1826
reflexa (t. 283)	summer 1822
refulgens (t. 284)	1819
serpyllifolia (t. 289)	summer 1826
transparens (t. 296)	February 1820
undulata (t. 300)	summer 1828

Thus there are illustrations in vol. 5 that were not prepared until 1816, and the final illustration in vol. 6 was not completed until the summer of 1828.

CONCLUSION

As long as it is accepted that *The Heathery* was published as a sequence of separate, intact volumes, the watermarks in vol. 5 indicate a publication date not earlier than 1815 and the raising and blooming dates corroborate that year, whereas the dates on which the plates were drawn, imply that this volume cannot have been issued before 1816 when Andrews drew *E. splendens* (t. 240).

Regarding vol. 6, the watermarks signal that it cannot have appeared earlier than 1826, whereas the raising and blooming dates point to publication late in 1828, a date that is confirmed by the fact that Andrews only drew *E. undulata* (t. 300) in the summer of 1828.

We conclude that the dates of publication of H.C. Andrews' *The Heathery* are: Volume 1: not before June 1805; Volume 2: not before 1806; Volume 3: 1806; Volume 4: 1807; Volume 5: not before 1816; Volume 6: late 1828.

As a consequence, it can be concluded that most, if not all, of H.C. Andrews' new names for *Erica* species were first published in *Coloured engravings of heaths.*

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Embryology and systematic relationships of *Kiggelaria* (Flacourtiaceae)

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Keywords: Achariaceae, embryology, Flacourtiaceae, *Kiggelaria* L., ovule structure, seed coat

ABSTRACT

Kiggelaria L. is endemic to Africa and the only representative of tribe Pangieae (Flacourtiaceae) on the continent. Molecular genetics, phytochemistry and host-parasite relationships have indicated a relationship between this woody, pantropical tribe of Flacourtiaceae and a small, trigeneric family of herbaceous, southern African endemics, the Achariaceae. In the present study, ovule and seed structure in *Kiggelaria* were investigated and compared with relevant data recently reported for Achariaceae. Support for an alliance with Achariaceae were found in the presence of anatropous, bitegmic, sessile ovules with zigzag micropyles, deep-lying embryo sacs covered by an epistase in the ovule and seed, endotestal-exotegmic seed coat layers, suspensorless embryos and sarcotestal seed with a prominent, plate-like hypostase. Unlike Achariaceae, *Kiggelaria* seeds do not have chalazal seed lids, pronounced raphal ridges, a fringe layer, or stomata in the outer epidermis of the sarcotesta. Structural dissimilarities in seeds of ornithochorous *Kiggelaria* and myrmecochorous Achariaceae were regarded as adaptations linked to different strategies for seed germination and dispersal.

INTRODUCTION

Kiggelaria L. is a widely distributed, wholly African genus of dioecious trees and shrubs. It occurs in all the provinces of the Republic of South Africa and in Lesotho, Swaziland, Namibia, south tropical Africa and tropical East Africa as far north as Mount Kilimanjaro (Killick 1976a). In these areas *Kiggelaria* represents an important floristic element of forest in the archipelago-like Afromontane Region of Endemism (White 1978). This African phytocorion is of special biogeographical and evolutionary significance because of its putative ancient status. Although the genus shows considerable variability in juvenile and mature vegetative morphology, only one polymorphic species is currently recognized, namely *Kiggelaria africana* L. (Killick 1976b).

In most modern suprageneric classification systems of Flacourtiaceae, *Kiggelaria* is placed within the tribe Pangieae. This tribe of about 10 genera has a disjunct, pantropical distribution (Wendt 1988) with most genera reported from Malaysia (Chase *et al.* 2002). *Chiangiodendron* T.Wendt occurs in southeastern Mexico (Wendt 1988), *Baileyoxylon* C.T.White is found in Australia and *Kiggelaria* is the only representative from Africa. Alternatively, *Kiggelaria* and other genera of the Pangieae have been treated as a separate family, Kiggelariaceae (Savolainen *et al.* 2000; Soltis *et al.* 2000). Within Flacourtiaceae, the Pangieae form a more or less homogeneous group that, in terms of generic content, has remained consistent in taxonomic treatments (Hutchinson 1967; Lemke 1988; Takhtajan 1997). On account of comparative macromorphology, wood anatomy, palynology and the distribution of selected classes of chemical constituents, Lemke (1988) regarded the cyanogenic, relatively unspecialized flacourtiaceous tribes Berberidopsideae, Erythrospermeae, Pangieae and Oncobeae as closely related. He suggested that phylogenetic relationships among them and other cyanogenic families of Violales should be examined more carefully.

A possible phylogenetic link between one such family, namely Achariaceae, a family of three monogeneric genera from southern Africa, and the tribe Pangieae, particularly *Kiggelaria*, was first suggested by the breeding behaviour of a butterfly, *Acraea horta* (Nymphalidae: Heliconiinae: Acraeini) in the botanical garden of the University of Pretoria. This was reported by Dahlgren & Van Wyk (1988; see also Steyn *et al.* 2002b). Based on evidence from molecular biology, Chase *et al.* (1996) also suggested a linkage between the herbaceous Achariaceae and the woody tribe Pangieae. More recent phylogenetic molecular data reported by e.g. Soltis *et al.* (2000) and Savolainen *et al.* (2000) have provided additional support for a close association between *Acharia* Thunb., *Guthriea* Bolus (Achariaceae) and *Kiggelaria*. The third genus, *Ceratiosicyos* Nees, was not included in these investigations. Lately, Chase *et al.* (2002) proposed splitting Flacourtiaceae *sensu* Lemke (1988) and emending the circumscription of the families Achariaceae Harms and Salicaceae Mirb. Achariaceae *sensu* Chase *et al.* (2002) thus include Acharieae Benth. & Hook.f., Pangieae (*sensu auct.*), Erythrospermeae DC. and a newly described tribe, Lindackerieae Zmarzty (in Chase *et al.* 2002: 172, 173), all cyanogenic. The non-cyanogenic tribes of Flacourtiaceae *sensu* Lemke [Flacourtieae DC., Samydeae (Vent.) Dumort., Homalieae (R.Br.) Dumort., Scolopieae Warb., Prockieae Endl., Abatieae Hook.f. and Bembicieae Warb.] have been placed with Saliceae (*Salix* L. and *Populus* L.) and Scyphostegieae (Hutch.) Zmarzty in a much enlarged Salicaceae (Chase *et al.* 2002).

Apart from data provided by molecular phylogenetics, phytochemistry and host-parasite relationships, support for an alliance between Pangieae *sensu auct.* and Achariaceae Harms has rarely been offered. Steyn *et al.* (2002a, b) pointed out that the development and structure of mechanical seed coat layers in Achariaceae closely match those of *Kiggelaria* and *Hydnocarpus* Gaertn.

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(Pangieae) as described by Van Heel (1979). This resemblance suggests that a detailed comparison of ovule and seed characters might reveal additional similarities between *Kiggelaria* and Achariaceae. However, embryological data on *Kiggelaria* obtainable from literature were scant and ambiguous; we therefore re-investigated ovule and seed structure in *Kiggelaria africana.* The results of our study are given in the present report.

MATERIAL AND METHODS

Open flowers and developing fruit were collected from female trees in a dioecious, natural population of *Kiggelaria africana* growing in the National Botanical Garden, Pretoria, South Africa. To facilitate penetration of chemicals into ovules and seeds, the thick ovary wall was partly removed and developing seeds were removed from the locule. All material was fixed and stored in a 0.1 M cacodylate buffered solution containing 4% formaldehyde and 2.5% gluteraldehyde. Following the methods of Feder & O'Brien (1968), material was dehydrated in an alcohol series and impregnated with glycol methacrylate (GMA). All material was imbedded in GMA, sectioned transversely or longitudinally at 2–3 μm and subsequently stained with the periodic acid/Schiff reaction and toluidine blue O (pH 4.4) by using the protocols of O'Brien & McCully (1981).

RESULTS

Placentation and orientation of ovules

The unilocular, thick-walled and densely pubescent ovaries in female flowers (Figure 1) contain many ovules borne singly or in pairs on four or five parietal placentas. The sessile ovules are supplied by vascular strands connected to the large vascular bundles lying opposite the petals with their conspicuous, adaxial nectary glands (adnate adaxial basal scales, according to Chase *et al.* 2002). The position of the placental bundles in relation to the petals suggests that they represent the marginal bundles of the congenitally fused carpels. During the maturation of ovules, the space in the locule becomes restricted. The ovules are pressed against each other and the ovary wall, and pushed out of alignment with the micropyles pointing in all possible directions.

Structure of mature ovule

Ovules are anatropous, bitegmic, crassinucellate and ovoid in shape (± 530 × 400 μm) when the flowers open. Sagittal sections show that there is no funicle and the raphe is pronounced (Figure 2A). The vascular bundle of the raphe branches as it enters the overgrown chalaza, but the ramifications do not enter the integuments. Both integuments are multi-layered. The outer is thicker than the inner, especially at its distal rim where it overtops the inner integument to take part in the formation of the slightly zigzag micropyle canal (Figure 2A, B). At anthesis, the outer and inner epidermal layers of the outer integument are separated by about four layers of thin-walled, isodiametric mesophyll cells containing many, small starch grains and occasionally showing periclinal as well as anticlinal divisions. Periclinal divisions also occur in the inner epidermal cells of this integument, whereas the cells of the outer epidermis and the epidermis of the chalaza mostly divide anticlinally to form a layer of radially flattened cells (Figure 2A, B). The inner integument is about five layers thick and its cells are smaller than those of the outer integument, except for the outer epidermal cells of the inner integument which are elongate in the direction of the longitudinal axis of the ovule. A distinct cuticle layer separates the integuments from each other.

The ovoid, relatively small nucellus with enclosed embryo sac, lies in the centre of the ovule, occupying

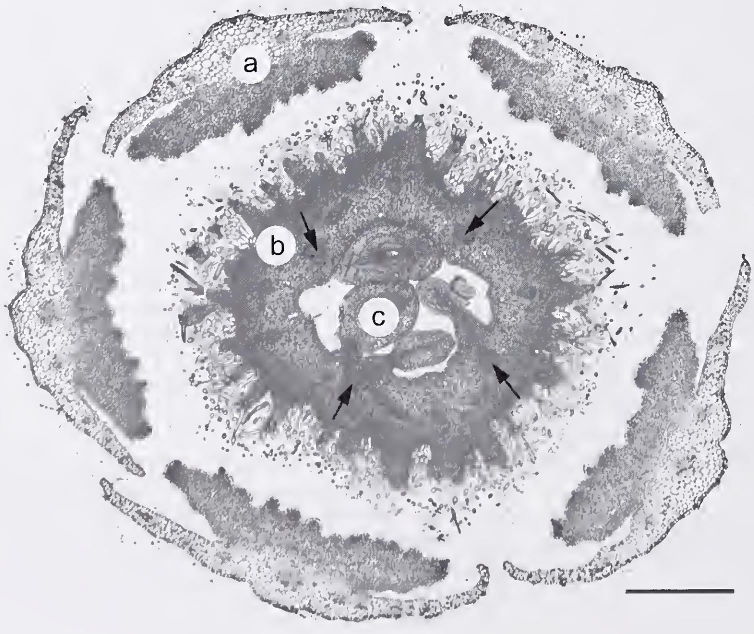

FIGURE 1.—Female flower of *Kiggelaria* in t/s (sepals removed). a, petal with adnate adaxial nectary gland; b, ovary with parietal placentae in antepetalous position; c, ovule. Note arrows indicating large vascular bundles that supply ovules. Scale bar: 500 μm.

about one-third of its length (Figure 2A, B). The micropylar nucellus consists of about eight cell layers and the nucellus epidermis contributes to the formation of this tissue by dividing once, periclinally. Below the nucellus epidermis, the parietal nucellus stains darkly on account of the thicker walls and large numbers of starch grains in

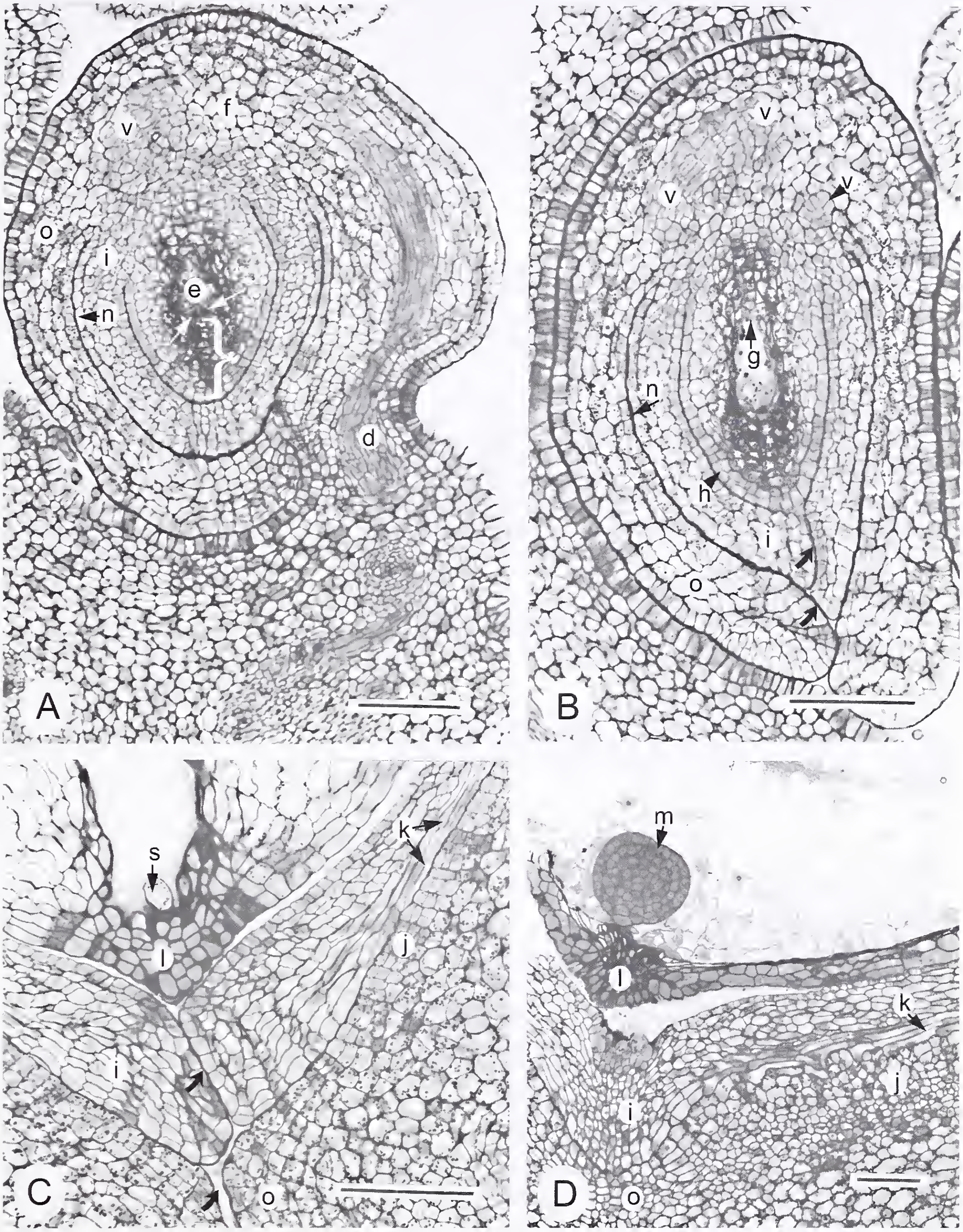

FIGURE 2.—Ovule and developing seed of *Kiggelaria*. A, structure of mature ovule in sagittal section. Note thick nucellus cap (white bracket) and filiform apparatus of synergids (white arrows); B, mature ovule in median l/s showing zigzag micropyle; C, micropylar part of young seed during resting stage of zygote; D, suspensorless embryo in micropylar part of developing seed. Curved arrows in B & C indicate zigzag micropyle; d, raphe; e, embryo sac; f, chalaza; g, antipodal cells; h, nucellus epidermis; i, inner integument; j, inner epidermis of testa; k, outer epidermis of tegmen; l, epistase; m, young embryo; n, outer epidermis of inner integument; o, outer integument; s, zygote; v, vascular bundle. Scale bars: 100 μm.

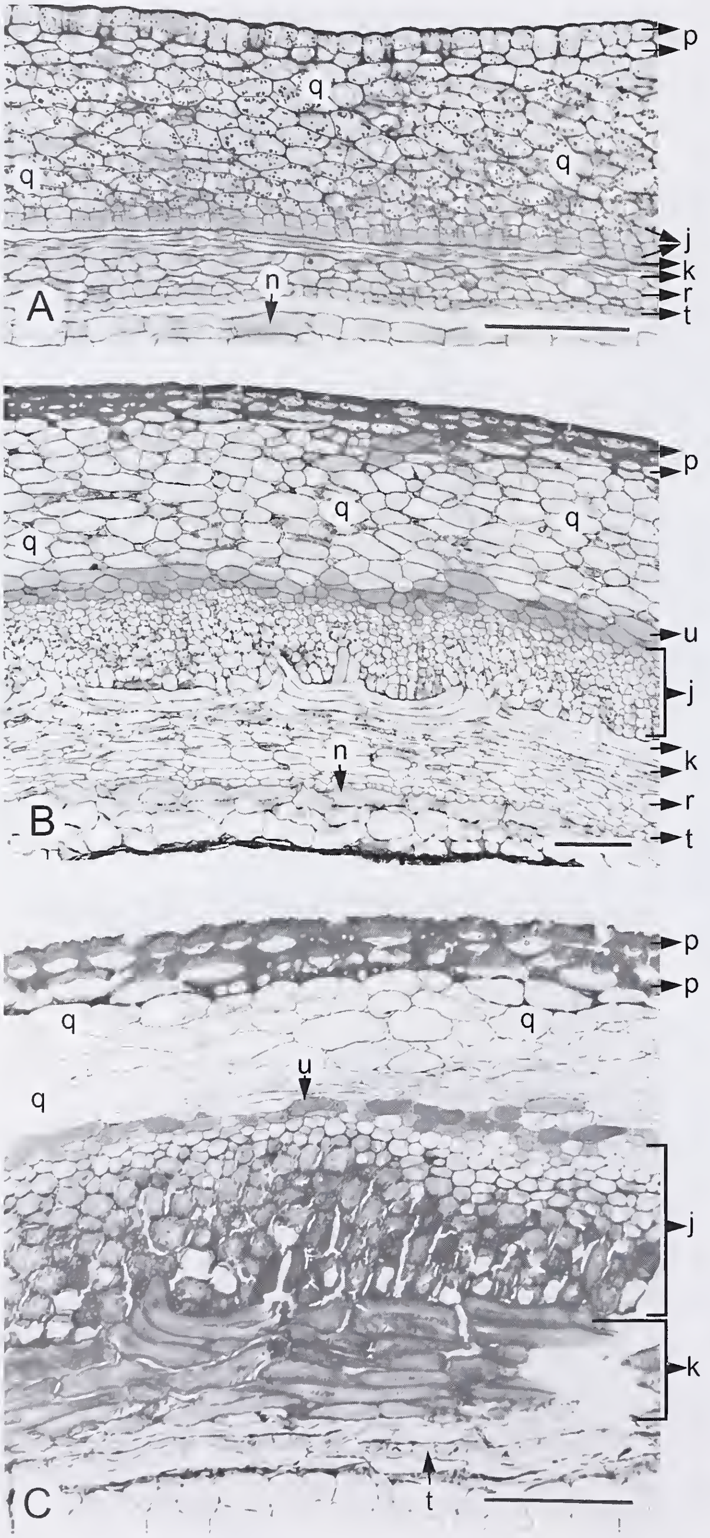

FIGURE 3.—Seed coat development in *Kiggelaria*. A, zygote stage of embryo; B, when endosperm becomes cellular; C, dispersed seed. j, inner epidermis of testa; k, outer epidermis of tegmen; n, nucellus epidermis; p, outer epidermis of testa; q, succulent mesophyll of sarcotesta; r, mesophyll of tegmen; t, inner epidermis of tegmen; u, darkly stained layer of sarcotesta. Scale bars: 100 µm.

the cells. The inner layers of the lateral nucellus and the column-like nucellus below the embryo sac (postament, according to Shamrov 1998) show a similar staining reaction.

The pear-shaped embryo sac of the mature ovule thus lies deeply imbedded in nucellar tissue. The narrow chalazal end contains three small antipodal cells (Figure 2B). The nucleus of the central cell lies in the centre, adjacent to the wall, whereas the egg apparatus occupies the wider, micropylar region. The position of the two synergids with darkly stained, well-formed filiform apparatus (Figure 2A), clearly indicates the distal limits of the embryo sac. Reports that the tip of the embryo sac of *Kiggelaria* breaks through the nucellus tissue and enters the micropyle (Johri *et al.* 1992) are not substantiated by the present study.

Seed and seed coat development

Fertilized ovules enlarge rapidly and endosperm formation precedes embryo development. During the free-nuclear stage of the endosperm, the zygote remains in a resting phase directly below the micropyle (Figure 2C) and is separated from the endostome by the thick-walled remnants of the nucellus cap that form an epistase. This tissue plugs the micropyle (Bouman 1984) and it persists in later stages of embryo development (Figure 2D).

The embryogeny of *Kiggelaria* was not studied in detail; pro-embryos were not found in our material and the embryo could not be typified. When the seed reaches its final size of about 6 mm, the free-nuclear endosperm becomes cellular. The embryo then is in the early heart-shaped stage and has no suspensor (Figure 2D). By the time the capsule splits open to release the ripe, bright orange-red seeds, the embryo lies in the centre of the endosperm, has thin, spatulate cotyledons and is of medium size, i.e. it extends about halfway up into the endosperm.

Contribution of the outer integument (testa) to the seed coat

The outer integument is strongly multiplicative and all cell layers contribute to the formation of the mature seed coat. The outer epidermis divides periclinally once or twice (Figure 3A) and the resulting epidermal tissue eventually acquires unevenly thickened cell walls to form a collenchymatous pellicle (Figure 3B, C). This protective layer also covers the chalaza and raphal region of the seed and contains no stomata. The cells of the mesophyll below the epidermis of the integument, raphe and chalaza divide in various planes to develop into the multi-layered, thin-walled, succulent tissue of the sarcotesta (Figure 3A–C). In the ripe seed, the contents of the innermost cells of the sarcotesta reacts strongly with PAS and toluidine blue. These dark-staining cells form a layer that separates the sarcotesta from the mechanical tissue (Figure 3B, C). It is in this position that a fringe layer occurs in the three genera of the Achariaceae (Steyn *et al.* 2002a, b), but such a layer is absent in *Kiggelaria.*

The outer integument contributes to the protective, mechanical tissue of the seed coat. This tissue has a dual derivation and consists of two sub-layers. The outer layer originates from the inner epidermis of the outer integument; the inner layer from the outer epidermis of the inner integument (see further on). The cells of the inner epidermis start dividing periclinally just after fertilization to form radial rows of cells (Figures 2C; 3A). The rows later become disrupted, because the outer cells undergo further divisions in various planes, the inner cells increase in size and the developing exotegmic fibres start intruding into the endotestal layers (Figures 2D; 3B, C). At seed dispersal stage, the large cells of the endotesta have developed into thick-walled, isodiametric sclereids (Figure 3C). The outer, smaller cells of the endotesta remain relatively thin-walled and separate the sclereids from the layer of dark-staining sarcotestal cells (Figure 3C). At the chalazal end of the seed, the layers of relatively thin-walled, endotestal cells continue into the chalaza, surround the vascular tissue and separate the latter from a thin, plate-like layer of lignified cells that represents a hypostase (not illustrated).

Contribution of the inner integument (tegmen) to the seed coat

The inner sub-layer of the mechanical tissue is exotegmic and originates from the outer epidermis of the inner integument. The cells divide periclinally and cells are formed centripetally (Figures 2C; 3A). The derivatives rapidly stretch in a direction parallel to the longitudinal axis of the seed (Figures 2C, D; 3B, C). At this stage the cuticle between the two developing sub-layers is still distinct. When the endosperm becomes cellular, the tips of the elongated exotegmic cells start intruding into the adjacent sub-layer of endotestal tissue (Figures 2D; 3B) and the cuticle becomes disrupted. At seed dispersal stage the endotegmic sub-layer has matured into thick-walled, longitudinally orientated fibres (Figure 3C). This sub-layer does not continue into the chalaza.

The mesophyll and inner epidermis of the inner integument do not play a significant role in the structure of the mature seed coat; the layers disintegrate when the endosperm tissue matures (Figure 3C). The cuticle between the nucellus and inner epidermis of the inner integument, so prominent in seeds of *Guthriea* (Steyn *et al.* 2001), is thin. A pigment layer that, according to Van Heel (1979), differentiates on the inside of the sclereid layer in *Kiggelaria* (also *Hydnocarpus*) and persists when the mesophyll disintegrates later on, was not seen during this investigation.

DISCUSSION

For most of the 80–95 genera traditionally placed in Flacourtiaceae (e.g. Hutchinson 1967; Lemke 1988) and recently split in two groups to expand the families Achariaceae and Salicaceae (Chase *et al.* 2002), embryological characters are completely unknown. The meagre, scattered data used to compile accounts of Flacourtiaceae in compendia dealing with comparative embryology (e.g. Davis 1966; Johri *et al.* 1992) provide no support for the ‘sweeping taxonomic changes’ proposed by Chase *et al.* (2002). However, two embryological studies do suggest that such changes might have merit. Firstly, a recent study on members of Flacourtiaceae *sensu lato* with a multi-whorled androecium (Bernhard & Endress 1999), showed that the stamens are initiated centrifugally in Flacourtieae and Scolopieae (non-cyanogenic tribes) as reported for *Populus* in Salicaceae Mirb. (Kaul 1995). In Erythrospermeae, Oncobeae (except *Oncoba)* and Pangieae (cyanogenic tribes) initiation is centripetal or simultaneous. Achariaceae, however, are characterized by a single whorl of 3–5 stamens (Dahlgren & Van Wyk 1988; Bernhard

TABLE 1.—Comparison of selected ovule and seed characters in *Kiggelaria* and Achariaceae Harms

No.	Character	*Kiggelaria*	*Acharia*, *Guthriea* and *Ceratiosicyos* (Steyn *et al.* 2002a, b)
1.	Ovule position and number	Parietal, multi-ovular.	Parietal, multiovular in *Guthriea* and *Ceratiosicyos*, tetra-ovular in *Acharia.*
2.	Ovule type	Anatropous, bitegmic, crassinucellate.	Anatropous, bitegmic, crassinucellate.
3.	Outer integument	Multilayered, overtops inner in ovule and seed.	Multilayered, shorter than inner in ovule (*Ceratiosicyos*), overtops inner in ovule and seed (*Acharia, Guthriea*).
4.	Inner integument	Multilayered, outer epidermal cells not conspicuously elongate in l/s of ovule, first divisions periclinous.	Multilayered, outer epidermal cells conspicuously elongate in l/s of ovule, first divisions anticlinous, then periclinous.
5.	Micropyle canal	Zigzag, formed by both integuments in ovule and seed.	Zigzag, formed by both integuments in ovule and seed (*Acharia*, *Guthriea*); straight, formed by inner integument in ovule, both integuments in seed (*Ceratiosicyos*).
6.	Raphe	Pronounced in ovule, not forming a ridge in seed.	Pronounced to form a ridge in ovule and seed (*Acharia*, *Guthriea*); not pronounced in *Ceratiosicyos.*
7.	Funicle	Absent, ovule and seed sessile.	Variable in length (*Ceratiosicyos*) or absent (*Acharia*, *Guthriea*).
8.	Nucellus cap	Comprises derivatives of nucellus epidermis and parietal cell, separates embryo sac from endostome, eventually forms epistase.	Comprises derivatives of nucellus epidermis and parietal cell, separates embryo sac from endostome, eventually forms epistase.
9.	Embryo sac	Monosporic, eight-nucleate, *Polygonum* Type (Johri *et al.* 1992, requires confirmation).	Bisporic, eight-nucleate, *Allium* Type.
10.	Seed type	Anatropous, sarcotestal, endospermous.	Anatropous, sarcotestal, endospermous.
11.	Hypostase	Present as plate-like layer of lignified cells in mature seed.	Present as plate-like layer of thin-walled cells with phenolic substances (*Ceratiosicyos*) or crystals (*Acharia, Guthriea*) in mature seed.
12.	Perisperm	Absent.	Present in *Acharia* and *Guthriea*, absent in *Ceratiosicyos.*
13.	Seed size	Medium, ± 6 mm long.	Medium, ± 6 mm long.
14.	Embryo type	Unknown, suspensorless.	*Penaea* variation of Asterad Type, suspensorless.
15.	Embryo size	Medium, ± 4 mm.	Medium, ± 4 mm (*Ceratiosicyos*), small, < 2 mm (*Acharia*, *Guthriea*).
16.	Epidermis of sarcotesta	Multilayered collenchymatous pellicle, hairs and stomata absent.	Unilayered, glabrous with stomata (*Ceratiosicyos*), multilayered, collenchymatous pellicle, hairs and stomata present (*Acharia*, *Guthriea*).
17.	Mesophyll of sarcotesta	Succulent outer layers, fringe layer absent in inner layer.	Succulent outer layers, inner layer forms fringe layer.
18.	Mechanical layers in seed	Endotestal sclereids + exotegmic longitudinal fibres.	Endotestal sclereids + exotegmic longitudinal fibres.
19.	Chalazal seed lid	Absent.	Absent in *Ceratiosicyos*, present in *Acharia*, *Guthriea.*
20.	Dispersal mechanism	Autochory + ornithochory.	Autochory (*Ceratiosicyos*), autochory + myrmecochory (*Acharia*, *Guthriea*).

1999). Secondly, an earlier work on seed coat structure by Corner (1976) indicated that the family should be divided in two groups, namely a *Flacourtia* group (*Casearia* Jacq., *Flacourtia* L'Hér., *Idesia* Maxim., *Oncoba* Forssk.) and a *Hydnocarpus* group (*Hydnocarpus*, *Kiggelaria*, *Pangium* Reinw., *Scaphocalyx* Ridl.).

Corner (1976) mistakenly interpreted the seeds of all investigated members of his *Hydnocarpus* group as pachychalazal with no contribution of the integuments towards the formation of mechanical seed coat layers. Van Heel's (1974, 1979) studies showed that the seed coat of only *Pangium* is pachychalazal; *Erythrospermum* Lam., *Hydnocarpus* and *Kiggelaria* have seed coats with endotestal-exotegmic mechanical layers, but the integumental derivation and dual origin of the mechanical layers are masked by the early disappearance of the cuticle boundary. In *Caloncoba* Gilg and *Camptostylus* Gilg (Lindackerieae) the cuticle separating the inner and outer integument also vanishes entirely during seed formation (Van Heel 1977). Results obtained during the present study confirm Van Heel's (1979) observations on *Kiggelaria.* Seed coat structure in Pangieae, Erythrospermeae and Lindackerieae therefore corresponds to Achariaceae Harms as described by Steyn *et al.* (2002a, b), providing embryological support for emending the circumscription of Achariaceae as proposed by Chase *et al.* (2002).

A second embryological character of *Kiggelaria* that needed clarification is the shape of the embryo sac. Davis (1966) reported that the embryo sac of *Kiggelaria* does not become much elongated, while Johri *et al.* (1992) found the embryo sac in *Kiggelaria* similar to that of *Azara* Ruiz & Pav. (= *Arechavaletaia* Speg.) with an embryo sac breaking through the nucellus and reaching the exostome of the micropyle. An 'extra-nucellar embryo sac' (Johri *et al.* 1992: 549) also occurs in *Flacourtia* (Johri *et al.* 1992) and approaches the state described for Salicaceae Mirb. where the tip of the embryo sac comes into contact with the integument (Chamberlain 1897; Maheshwari & Roy 1951; Johri *et al.* 1992). This type of elongated embryo sac may well be characteristic for Salicaceae *sensu* Chase *et al.* (2002). Our results on *Kiggelaria* show that the tip of the embryo sac, clearly indicated by the filiform apparatus of the synergids, remains covered by the nucellus cap (Figure 2C, D) as reported for Achariaceae (Steyn *et al.* 2001, 2002a, b). The nucellus cap later forms an epistase, separating the zygote and embryo from the micropyle. The presence of an epistase is another clear indication that the tip of the embryo sac stays inside the nucellus. An epistase is only known in a few angiosperm families (Bouman 1984) and was recently reported for Achariaceae (Steyn *et al.* 2001, 2002a).

A detailed comparison of ovule and seed structure in *Kiggelaria* and Achariaceae (Table 1) shows additional noteworthy similarities, such as the contribution of the nucellus epidermis to nucellus cap formation, sessile ovules with zigzag micropyles (not *Ceratiosicyos*), suspensorless embryos and sarcotestal seeds. The latter two characters may be important markers for Achariaceae *sensu* Chase *et al.* (2002); the embryo of at least *Idesia* (Flacourtieae) has a long suspensor (Johri *et al.*1992), while sarcotestal seeds were also reported for *Caloncoba* Gilg and *Camptostylus* Gilg (Lindackerieae) by Van Heel (1977). In the recently circumscribed Salicaceae the seeds are not sarcotestal, but are often arillate (Chase *et al.* 2002).

With regard to ovule characters, *Kiggelaria* seems closer to *Acharia* and *Guthriea* than to *Ceratiosicyos* (Table 1: Nos 3, 5, 6 & 7). Some structural dissimilarities between *Kiggelaria* and Achariaceae Harms (see Nos 6, 16 & 17) can possibly be linked to specific adaptations for seed dispersal (see Steyn *et al.* 2002a for details); *Kiggelaria* seeds are bird-dispersed (Palmer & Pitman 1972) whereas *Acharia* and *Guthriea,* but not *Ceratiosicyos*, are adapted to dispersal by ants. It is noteworthy that seeds of *Kiggelaria* and *Ceratiosicyos*, both having relatively large embryos, lack the seed lid found in seeds of *Acharia* and *Guthriea.* The absence of such a lid in *Kiggelaria* supports our hypothesis (Steyn *et al.* 2002a, b) that this peculiar device is a specific adaptation to seed germination for the small, slow-maturing embryos in seeds of *Acharia* and *Guthriea*.

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Vegetation of the rock habitats of the Sekhukhuneland Centre of Plant Endemism, South Africa

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Keywords: biodiversity, Braun-Blanquet, conservation, endemism, phytosociology, Sekhukhuneland, syntaxonomy, ultramafic rock habitats

ABSTRACT

A hierarchical classification, description, and ecological and floristic interpretations are presented on the vegetation types of the ultramafic rock habitats of the Sekhukhuneland Centre of Plant Endemism. Relevés were compiled in 100 stratified random plots. A TWINSPAN classification, refined by Braun-Blanquet procedures, revealed 17 plant communities, which are classified into 13 associations belonging to four proposed alliances. Many new syntaxa are ecologically interpreted and described. For each syntaxon, the species richness, endemism and conservation status was determined. Much of the plant community distribution can be ascribed to specific habitat preference. The floristic and habitat information, proposed classification, general description and vegetation key are provided to aid future identification of conservation areas, land use planning and research. An ordination (DECORANA) based on floristic data confirmed potential relationships that could exist between the plant communities and associated habitats and environmental gradients.

INTRODUCTION

Although several phytosociological studies have been conducted on vegetation types of the northeastern Drakensberg Escarpment and adjacent areas of Limpopo [Northern Province] and Mpumalanga (Deall 1985; Bloem 1988; Matthews 1991; Burgoyne 1995), the vegetation of the Sekhukhuneland Centre of Plant Endemism (SCPE) (Van Wyk & Smith 2001; Siebert & Van Wyk 2001) has never been studied in detail. Recently much work has been done to document the plant diversity and vegetation of this poorly known micro-regional Centre of Plant Endemism (Siebert *et al.* 2002a–e; Siebert *et al.* 2003). The vegetation of rock habitats is the last major vegetation type of Sekhukhuneland to be described. Its extent of occurrence is ± 4 000 km^2 and is characterized by considerable diversity in geology (Kent 1980) and physiography (Land Type Survey Staff 1987). In South Africa rock outcrop communities have received very little attention from botanists and environmentalists in the past (Bredenkamp & Deutschlander 1995), probably due to their low agricultural potential. However, ultramafic rock habitats are floristically noteworthy and have high conservation significance, because many endemics with distributions correlated with this geological substrate occur here (Madulid & Agoo 1995; Meirelles *et al.* 1999; Reddy *et al.* 2001; Siebert *et al.* 2001).

Various vegetation types have been identified for the rock habitats of the northeastern Drakensberg Escarpment (Matthews *et al.* 1991; Matthews *et al.* 1992) and western Rustenburg Layered Suite (Coetzee 1975; Van der Meulen 1979), areas that have a strong floristic relationship with the SCPE (Siebert 1998). The areas where the rocky outcrops of the SCPE occur were mapped as three major Veld Types by Acocks (1988), namely Mixed Bushveld (18), Sourish Mixed Bushveld (19) and North-Eastern Sandy Highveld (57). A more generalized classification of the same region's vegetation is given by Low & Rebelo (1996), who recognize one broad Vegetation Type for the study area, namely Mixed Bushveld (18).

The vegetation of the SCPE can be broadly described as mountain bushveld that forms a mosaic with moist grassland in the south and semi-arid bushveld in the north. In this region of undulating hills and mountains, a predominant and characteristic feature is the scattered rock habitats. The vegetation of rock habitats described here only includes those plant communities identified as the *Hippobromus pauciflorus–Rhoicissus tridentata* Rock Outcrop Vegetation by Siebert *et al.* (2002a). This vegetation forms a mosaic distribution with the other major vegetation types of the SCPE. Forty-one of the Sekhukhuneland endemics/near-endemics and threatened taxa are known to occur in rock habitats (Siebert 1998).

The present paper forms part of a comprehensive vegetation and floristic survey of the SCPE (Siebert 2001). It is envisaged that the identification, classification and description of the various vegetation units will contribute to the knowledge of the plant diversity and biological intricacies of the region. This paper provides ecological and floristic data of the region's rocky habitat communities on ultramafic outcrops and associated habitats, by characterizing and interpreting the vegetation units. Classification of the vegetation is basic to the formulation of management policies to co-ordinate and implement proper land use in bioregional planning activities. An assessment of the plant diversity, endemism and Red Data List taxa of the plant communities of the study area is supplied to aid future conservation actions and ecosystem management strategies. Such information is needed to build an adequate database of natural features and other land uses related to sustainable development (Bedward *et al.* 1992).

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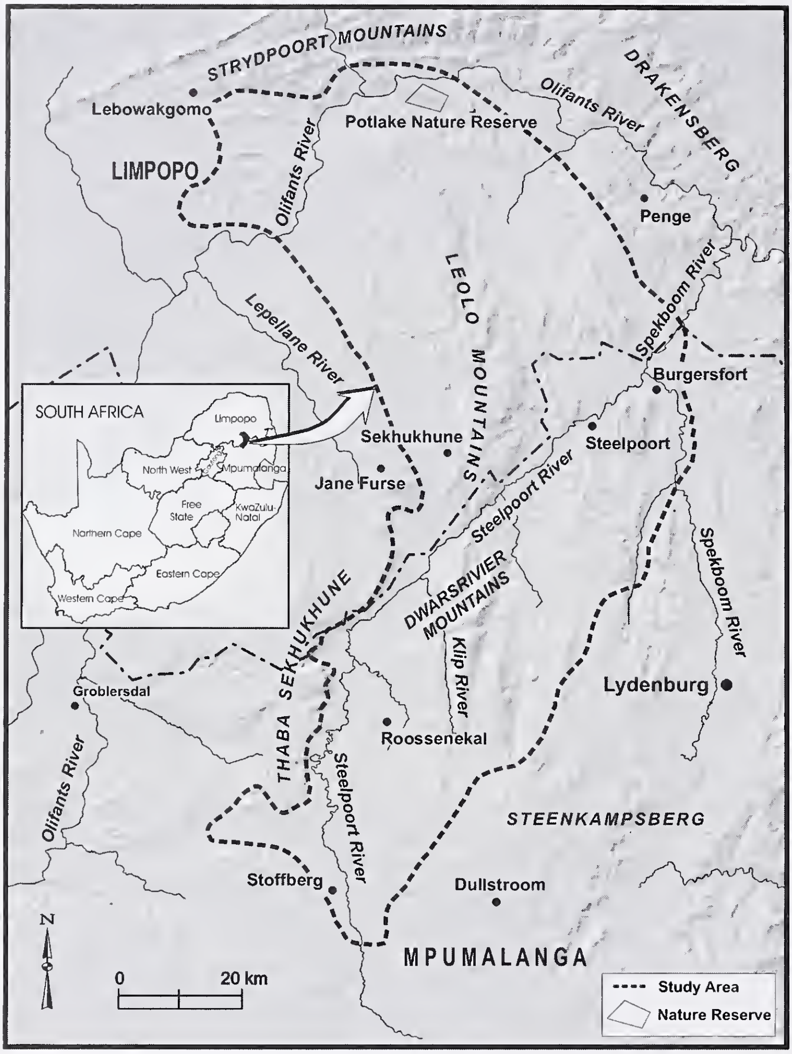

FIGURE 1.—Extent of occurrence of rock habitats of Sekhukhuneland Centre of Plant Endemism in Limpopo [Northern Province] and Mpumalanga, South Africa.

STUDY AREA

The study area is located in the SCPE and is defined in Siebert *et al.* (2002a) as an area more or less restricted to the Rustenburg Layered Suite, one of the stratigraphic units of the Bushveld Complex (Figure 1). The Rustenburg Layered Suite is known for its concentric belts of norite and pyroxenite (Visser *et al.* 1989). In addition, large quantities of heavy metals such as iron, chromium and platinum are present in the different zones of the suite (Schurmann *et al.* 1998; Viljoen & Schurmann 1998).

The study area lies in the summer rainfall region and the mean annual rainfall is 578 mm (South African Weather Bureau 1998), of which nearly half (48%) is received between December and February (summer); a mean of 283 mm for these three months (Erasmus 1985). However, the rainfall pattern is strongly influenced by the local topography and varies from as little as 400 mm in the Steelpoort and Olifants River valleys in the north, to an estimated 700 mm on the Leolo Mountains and the Dwarsrivier Mountains in the south (Siebert 1998). Perhaps the most outstanding climatic feature of the drier central and northern parts of the SCPE is that it lies in the rainshadow of the northeastern Drakensberg Escarpment.

Annual temperatures of the study area range from -4.5°C to 38°C, with a daily mean of 18.5°C (South African Weather Bureau 1998). The northern and western parts of the study area are on average warmer than the southern and eastern parts (Siebert 1998). The northern parts of the region exhibit mean daily temperatures of 28.3°C maximum and 7.2°C minimum. Temperatures vary at different localities within the area, also correlating strongly with physiographic features, being higher in the low-lying valleys and lower on the high-lying plateau (Buckle 1996).

METHODS

A first approximation of a vegetation classification, based on the total floristic data set of 415 stratified random sample plots (Siebert *et al.* 2002a) was obtained by the application of Two-Way Indicator Species Analysis

(TWINSPAN) (Hill 1979a). This first step of an objective multivariate classification identified six major vegetation types for the Sekhukhuneland Centre (Siebert *et al.* 2002a). These results were used to subdivide the data set into phytosociological tables. One of these tables represented floristic and habitat data of rock habitats (100 relevés) and was again subjected to TWINSPAN. The resultant classification was further refined by Braun-Blanquet procedures in the MEGATAB computer programme (Hennekens 1996b).

For sampling purposes, stratification was based on terrain type, aspect and vegetation structure. To standardize the plot size and to counter the bias of different scale (Jonsson & Moen 1998), plot size was fixed at 400 m^2. Within each sample plot, all species were recorded and a cover-abundance value was assigned to each species according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Plant species names conform to those of Retief & Herman (1997), and practice followed in the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria. Terminology to describe vegetation structure follows Edwards (1983). Environmental data recorded for each sample plot include terrain type (Land Type Survey Staff 1987, 1988, 1989), aspect, slope, geology (Visser *et al.* 1989), soil type (MacVicar *et al.* 1991) and rockiness of soil surface. Longitude and latitude readings were also recorded for each sample plot using a Global Positioning System (GPS). All relevé data are stored in the TURBOVEG database (Hennekens 1996a), managed by the Department of Botany, University of Pretoria (Mucina *et al.* 2000). Syntaxa are named in accordance with the Code of Phytosociological Nomenclature (Weber *et al.* 2000).

The ordination algorithm Detrended Correspondence Analysis (DECORANA) (Hill 1979b) (Figure 2) was applied to highlight potential gradients in the vegetation, and the relationship between these plant communities and the physical environment.

To facilitate the identification of areas of high conservation potential, the alpha diversities of the different plant communities were calculated. The alpha diversity (plant species richness) is defined as the number of species per unit area within a homogeneous community or the total number of species per community (Whittaker 1977). A 400 m^2 sample plot was taken as the unit area.

The geographical distribution of all the taxa was verified at the National Herbarium (PRE), Pretoria, to identify any taxa endemic/near-endemic to the region (Siebert 1998). All taxa were also checked against the Red Data List of southern African plants (Hilton-Taylor 1996) to determine their conservation status.

RESULTS

Classification of vegetation

The floristic data analysis resulted in the identification of 17 plant communities of the *Hippobromus pauciflorus–Rhoicissus tridentata* Rock Outcrop Vegetation (Table 1). These were subsequently hierarchically classified into 13 associations. Four major syntaxa are recognized on the grounds of the physical environment and are proposed as potential alliances, with all 13 associations and eight subassociations classified under them. No macro-climatic or geological variation plays a role in

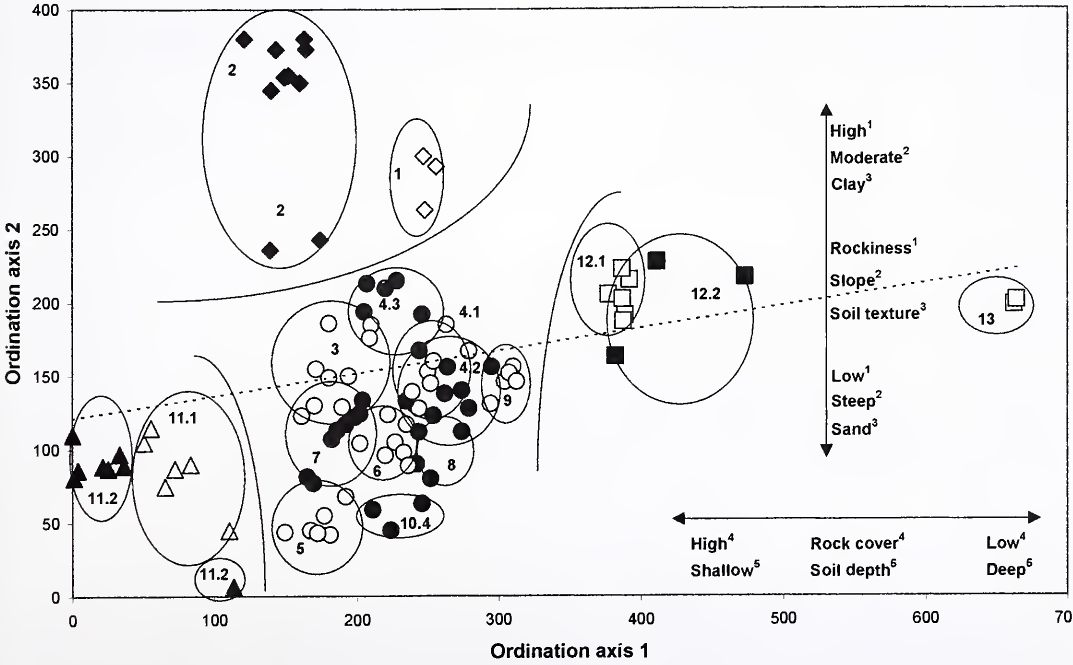

FIGURE 2.—Relative positions of all relevés along first and second axis of ordination of rock habitat vegetation in Sekhukhuneland Centre of Plant Endemism. Numbers refer to plant communities in Table 1.

TABLE 1.—Phytosociological table of vegetation of rock habitats in Sekhukhuneland Centre of Plant Endemism

Relevé number	125	190	215	122	123	185	195	222	243	245	286	289	401	129	130	138	153	224	230	231	242	247	16	17	27	38	39	40	41	83	80	81	82	84	85	96	313	18	19	20	50	295	296	317	7	15	24	71	99	105	108	45	51	55	59	60	62	93	54	107	136	225	240	246	315	320	324	4	12	74	75	76	334	338	339	1	29	30	32	35	68	58	87	91	97	98	134	244	278	67	69	70	79	88	103	72	182	227	406	407
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Association	1			2										3									4.1								4.2							4.3							5							6							7						8			9					10.4			11.1						11.2								12.1						12.2			13	
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Mimusops zeyheri	+	1	+	.	.	.	.	.	.	.	R	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	R	.	.	.	.	.	.	.	.	R	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Heteropyxis natalensis	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhoicissus tomentosa	+	.	+	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Secamone filiformis	R	+	R	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pittosporum viridiflorum	.	R	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Abrus laevigatus	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group B																																																																																																										
Commiphora marlothii	.	.	.	1	1	+	1	+	1	1	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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Hypoestes aristata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	R	.	R	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	R	.
Aristida canescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	+	.	.	.	.	.	.	R	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Ficus craterostoma	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	+	.	.	.	.	.	R	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	+	R	.	.	.

TABLE 1.—Phytosociological table of vegetation of rock habitats in Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé number	125 190 215	122 123 185 195 222 243 245 286 289 401	129 130 138 153 224 230 231 242 247	16 17 27 38 39 40 41 83	80 81 82 84 85 96 313	18 19 20 50 295 296 317	7 15 24 71 99 105 108	45 51 55 59 60 62 93	54 107 136 225 240 246	315 320 324	4 12 74 75 76	334 338 339	1 29 30 32 35 68	58 87 91 97 98 134 244 278	67 69 70 79 88 103	72 182 227	406 407
Alliance	I		II										III		IV		
Association	1	2	3	4.1	4.2	4.3	5	6	7	8	9	10.4	11.1	11.2	12.1	12.2	13
Species group G																	
Diospyros lycioides subsp. *nitens*	. . .	. . . .	. + R . . . R . .	. . . .	+ 1 . + 1 + .	. . . .	. . . .	. . . + R . .	. . . . . .	. R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Buddleja auriculata	. . .	. . . .	. . . .	. . . .	+ R + + . + .	. . . .	R . . . . R .	. . . . R . .	. . . . . .	. R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	R R
Triaspis glaucophylla	. . .	. . . .	. . . R	. . R	+ R + . 1 R .	. . . .	. . R . . . R	. . . .	. . . . . .	. . .	. . . . .	. . .	R	R . . . . . R .	. . . . . .	. . .	. .
Jasminum quinatum	. . .	. . . .	. . . .	. . . . . . R .	+ . . R . + +	. . . .	. . . . R . .	. . . .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Buddleja salviifolia	. . .	. . . .	. . . .	. . . .	R 1 R + R + .	. . . . R . .	. . R	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. R
Rhus rigida	. . .	. . . .	. . . .	. . . .	R + + + . + .	. . . .	. . . .	. . . . . . +	. . . . . .	. . .	. . . . +	. . .	. . . . . .	. . . .	. . . . . .	R . .	. .
Pupalia lappacea	. . .	. . . .	. . . .	. . . .	. + R . + + .	. . . .	. . . .	. . . .	. . . . . .	. R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group H																	
Crabbea angustifolia	. . .	. . . .	. . . .	R + . . . R + +	. R R . . . R	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Lantana rugosa	. . .	. . . .	. . . .	R + . + . R + R	+ R . . + . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Nidorella resedifolia	. . .	. . . .	. . . .	R + . + . . + R	R . + . . R .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Chlorophytum bowkeri	. . .	. . . .	. . . .	R R . . + . . +	. . + R + . .	. . . .	. . R . . + .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Tricholaena monachne	. . .	. . . .	. . . .	R . + . . . + .	. + . R . . R	. . . .	. . . .	. . . .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Peltophorum africanum	. R .	. . . .	. . . .	. . + . . + R .	+ + . . . + .	. . . .	. . . .	R + ...	. . . . . .	. . .	. . R . .	. . .	. . . . . .	. . . .	. . . . . .	R . R	. .
Heteromorpha trifoliata	. . .	. . . .	. . . .	. . R . + R . .	R + . . . + R	. . . .	. . . .	+ . . . . . R	. R	. R .	. . . . .	. . .	. . . . . .	. . . R R . . .	. . . . . .	. . .	. .
Species group I																	
Cheilanthes hirta	. . .	. . . .	. . . .	. . . .	R . + . . R .	+ + + R R . +	. . . .	+	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Sansevieria aethiopica	. . .	. . . .	. . . .	. . . .	. . . .	R + + + . . R	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Kalanchoe rotundifolia	. . .	. . . .	. . . .	. . . . R . . .	. . . .	R + . . + . R	. . . .	. . R	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Cyphostemma sp. B (*Siebert 1383*)	. . .	. . . R	. . . .	. . . . R . . .	. . . .	+ R R + . . .	. . . .	. . . .	. . . R . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. R R . . .	. . .	. .
Trachypogon spicatus	. . .	. . . .	. . . .	. . . .	. . . . . . +	R . + . . + +	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Aloe aculeata	. . .	. . . .	. . . .	. . . .	. . . .	+ . + . 1 1 +	. . . .	. . + ...	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Plectranthus xerophilus	. . .	. . . .	. . . .	. . . .	. . . .	R . . + . + .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Tripteris auriculata	. . .	. . . .	. . . .	. . . .	. . . .	R . . . R + .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Cyphostemma sp. A (*Van Wyk 13389*)	. . .	. . . R	. . . .	. . . .	. . . .	. R R R R R +	. R . . . . R	. . . R R . .	. . . . . .	. R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Sporobolus ioclados	. . .	. . . .	. . . .	. . . .	. . . .	. R R R . + +	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Gloriosa superba	. . .	. . . .	. . . .	. . . .	. . . .	. R . R R . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Chrysanthemoides monilifera	. . .	. . . .	. . . .	. . . .	. . . .	. . R . + 1 .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group J																	
Eragrostis chloromelas	. . .	. . . .	. . . .	1 + . . + 1 . R	R . + . + + +	. + . + . . +	. . . .	. . . .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Dombeya rotundifolia	. . .	. . . .	. . . .	+ + R + + + + +	. R . + 1 . R	R . + + . . .	. . . .	. . . .	. . R R . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. R . . R .	. . .	. .
Tetradenia riparia	. . .	. . . .	. . R + . . + . .	+ . . . + R + +	R + 1 . + + .	. 1 + 1 + + .	. . . .	. . . .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Cussonia paniculata	. . .	. . . .	. . . .	. + . R + . + .	. + + ...	R . . . + + .	. . . .	R . + . . R .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Grewia occidentalis	. . .	. . . .	. . . .	. + . . + . R +	+ . . . . + .	+ + + + . + +	. . . .	. + ...	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Seemannaralia gerrardii	. . .	. . . .	. . . .	. R . . . . + .	. . . R + . .	+ + R R . . .	. . . .	. . R	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Commelina benghalensis	. . .	. . . .	. . . .	. . R R R R R .	+ . . R . . +	. R R . . . R	R . R	. . . .	. . . . . .	. . .	R . . R .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Orthosiphon labiatus	+ + .	. . . .	. . . .	. . R . . + R R	1 . . . . R .	+ . 1 . . . +	. . . .	R	. . . . . .	. . .	. . . . .	. . .	. R + R R +	. . . .	. . . . . .	. . .	. .
Ficus ingens	. . .	. . . . R	. . . . . . R . .	. . . + . + . .	+ . . R + . .	. . R . + . .	. . . . . R .	. . . R . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group K																	
Croton gratissimus	1 + .	+ 1 1 1 1 1 1 . R +	+ . . + 1 R . R +	. + . + 1 1 + .	R . . . R . .	+ + 1 1 . . +	. . . .	+ R	. . . . . .	. . .	. . . . .	R . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Kirkia wilmsii	+ . R	. . R . . R . + + .	R + R + + . R R +	R . R R + . + .	. . R	A + A . + 1 .	. . . .	. . . .	R . . . . R	. . .	R . . R .	. . .	. . . . . .	. . . . . R . .	. . . . . .	. . .	. .
Setaria lindenbergiana	. + .	. + . + R + . 1 . .	+ + R . R . . R .	. + . 1 + . + +	. 1 . . 1 + .	. . + + . + +	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . R . R .	. . .	. .
Aloe cryptopoda	. . R	. R . . + . + + . +	+ + + . + + + + .	. + . . . R . +	. . + + . . +	. R . + + . R	. . . .	. . . .	. . . . + .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group L																	
Ruellia cordata	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	1 . + . . R .	. . . .	. . . . . .	. . .	+ . . . +	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Tenaris rubella	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	R . + R . R .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . . R . . .	. . . . . .	. . .	. .
Acalypha punctata	. . .	. . . .	. . . .	. . . .	. . . . . . R	. . . .	R . R 1 + . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . . + . . .	. . . . . .	. . .	. .
Aloe verecunda	. . .	. . . .	. R	. . . .	. . . .	. . . .	R . . . R + .	. . . .	. . . . . .	. . R	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Bulbostylis burchellii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	R . . + R . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Pearsonia aristata	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	R . . 1 . 1 +	. . . .	. . . . . .	. . .	. R R . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Brachiaria serrata	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. 1 1 + . + .	. . . .	. . + R . .	. . .	. . . . .	. . .	. . . . . .	. . . . + . . .	. . . . . .	. . .	. .
Scilla nervosa	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. + R . + . R	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhynchosia spectabilis	. . .	. . . . R R .	. . . .	. . . .	. . . .	. . . .	. + . + + R R	. . . + . . .	. R + . . .	R . .	. . . . .	. . .	. . . . . .	. . . . R . . .	. . . . . .	. . .	. .

TABLE 1.—Phytosociological table of vegetation of rock habitats in Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé number	125 190 215	122 123 185 195 222 243 245 286 289 401	129 130 138 153 224 230 231 242 247	16 17 27 38 39 40 41 83	80 81 82 84 85 86 313	18 19 20 50 295 296 317	7 15 24 71 99 105 108	45 51 55 59 60 62 93	54 107 136 225 240 246	315 320 324	4 12 74 75 76	334 338 339	1 29 30 32 35 68	58 87 91 97 98 134 244 278	67 69 70 79 88 103	72 182 227	406 407
Alliance	I		II										III		IV		
Association	1	2	3	4.1	4.2	4.3	5	6	7	8	9	10.4	11.1	11.2	12.1	12.2	13
Species group L (cont.)																	
Lotononis wilmsii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. + . + . R .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Pentanisia prunelloides	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. + . R + . R	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Aristida junciformis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. R . . + . R	. . . . R . .	R	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Tristachya rehmannii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . 1 + 1 . R	. . . .	R	. . .	. . . . .	. . .	. . . . . .	. . . . + . . .	. . . . . .	. . .	. .
Species group M																	
Brachylaena rotundata	R . +	. . . . R	. . + R	. . . .	. . . .	. . . .	. . . .	1 R 1 + . 1 .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Pearsonia sessilifolia	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	+ R . + R . +	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Grewia villosa	. . .	. . . .	. . . .	. R	. . . .	. . . .	. . . .	R + . R . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . R . . .	. . .	. .
Senecio oxyriifolius	. . .	. . . .	. . . .	. . . .	. . . . . . R	. . . . R . .	. . . .	R . 1 . + . .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Pachycarpus transvaalensis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. + . . R R .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhynchosia hirta	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. R . . . + R	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Solanum supinum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . R + . . 1	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Felicia filifolia	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . + . + R 1	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. + ...	. . . . . .	. . .	. .
Species group N																	
Dalechampia galpinii	. . .	. . . .	. . . . . R . . .	. . . R	. . . .	. . . .	. . . .	. . . .	+ R . . R +	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Aloe pretoriensis	. . .	. . . . + .	. . + ...	. . . .	. . . .	. . . .	. . . .	. . R . . . +	R 1 + + R 1	. . .	. . . . .	. . .	. . . . . .	. . R . + . . +	. . . . . .	. . .	. .
Justicia protracta	. . .	. . . .	. . . R R	. . . .	. . . .	. . . .	. . . .	. . . .	R + + . R .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Gnidia variabilis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	R . R . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Convolvulus sagittatus	. . .	. . . .	R . . . . R	. . . .	. . . .	. . . .	. . . . . . R	. . . . . . R	R . . + R +	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Gymnosporia buxifolia	. . R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . R + R .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . R	. .
Jatropha latifolia	. . .	. . . .	. . . . . . R . R	. . . .	. . . .	. . . .	. . . .	. . . .	. . R R R R	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group O																	
Tephrosia purpurea	. . .	. . . .	. . . + ...	. . . .	. . . .	. . . .	. . R R . . .	. . . .	. . . . . .	+ + +	. . . . .	. . .	. . . . . R	. . . . + . . .	. . . . . .	. . .	. .
Eragrostis curvula	. . .	. . . R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . R . . .	. . . . R .	+ + .	. . . . .	. . .	. . . R . .	. . . .	. . . . . .	. . .	. .
Zornia linearis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	+ R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Digitaria argyrograpta	. . .	. . . .	. . . .	. . . .	. . . . . . R	. . . .	. . . .	. . . .	. . . . . .	+ . +	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhynchosia minima	. . .	. . . .	. . . .	. . . .	. . . . . . R	. . . .	. . . .	. . . .	. . . . . .	R R R	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhus discolor	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	R R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Helichrysum albilanatum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	R . R	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Canthium mundianum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. + +	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhus sekhukhuniensis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. + R	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Hyparrhenia filipendula	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. + +	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Dioscorea sylvatica	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. R R	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group P																	
Apodytes dimidiata	R . R	. . . .	. . . . R . . . +	+ + . R + . . .	R + + 1 1 1 R	+ + . + + + .	+ R + . + + .	+ . . . + + .	. . . + . .	. R .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Zantedeschia pentlandii	. . .	. . . .	. . . .	R . R . . . + .	. . R . + . .	+ R + + 1 + .	+ + R . . + +	R . . + . R +	. + . R . +	. + .	. . . . .	. . .	R	. . R	. . . . . .	. . .	. .
Myrsine africana	. . .	. . . .	. . . .	R . . R	+ . + . . R .	. R . . + R R	. . . R . . .	. . + . . R +	. . . . . .	. . +	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	R R
Greyia radlkoferi	. . .	. . . .	. . . .	. R . . 1 + . .	+ . R . . 1 +	R . R	R . . . 1 + .	. R . + 1 . .	. R	+ . 1	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Cussonia transvaalensis	. . .	. . . . + R .	. . . . R . + . .	. . + + + + + +	+ + + . + + 1	. + + + 1 . .	+ . . . + + +	R + R + + + R	+ + 1 + + +	+ . +	. . . . .	. . .	. . . . . .	. . . .	. . . R . +	. . .	. .
Canthium suberosum	. . .	. . . .	. . . . R .	. . R . . . + .	. + . 1 + . .	. R . + . . R	R . . R + . .	+ . R . + + +	. . R + . .	. + .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhus zeyheri	. . .	. . . .	. . . .	. . R . . R . R	. R . + . . R	. . R R . . R	. . R . R R R	. R . + R + R	. . . . R .	+ . .	. . . . .	. . .	. . . . . .	. . . . R . . .	. . . . . .	. . .	. .
Diheteropogon amplectens	. . .	. . . .	. + ...	. . . R + . + +	R . . . R R .	+ . . . . + .	. + R . . + .	. + . 1 + . .	+ . + . . 1	. + .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group Q																	
Sporobolus fimbriatus	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	1 + 1 + .	. . .	. . . . . .	. . . .	. . . . . .	+ . .	. .
Scleria dieterlenii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	1 . 1 . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Rhamnus prinoides	. . .	. . . .	. . . .	. . . .	. . . . . R .	. . . .	. . . .	. . . .	. . . . . .	. . .	1 . + 1 +	. . .	. . . . . .	. . . .	. . . . . .	+ . .	. +
Freesia laxa	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	+ + + + R	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Leucosidea sericea	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	+ + . . +	. . .	. . . . . .	. . . .	. . . . . .	+ . .	+ .
Kalanchoe paniculata	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	R . + . +	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Cassinopsis ilicifolia	R . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. + . + .	. . .	. . . . . .	. . . .	. . . . . .	. . .	R .
Thunbergia atriplicifolia	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. + . . +	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group R																	
Catha transvaalensis	. . .	. . . .	. . . .	. . . .	. . . .	1 1 + + . . .	1 1 1 + . 1 1	+ 1 1 + . + .	. + . . . R	+ . R	1 + R . .	+ . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Olea capensis	. . .	. . . .	. . + ... R .	R . . . R . . .	. . . .	R + + + 1 . .	A 1 . . + 1 1	. + 1 . + 1 +	+ + . . + .	. 1 1	+ . . + +	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .

TABLE 1.—Phytosociological table of vegetation of rock habitats in Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé number	1 1 2	1 1 1 1 2 2 2 2 2 4	1 1 1 1 2 2 2 2 2		3	2 2 3	1 1		1 1 2 2 2	3 3 3		3 3 3		1 2 2	1	1 2	4 4
	2 9 1	2 2 8 9 2 4 4 8 8 0	2 3 3 5 2 3 3 4 4	1 1 2 3 3 4 4 8	8 8 8 8 8 9 1	1 1 2 5 9 9 1	1 2 7 9 0 0	4 5 5 5 6 6 9	5 0 3 2 4 4	1 2 2	1 7 7 7	3 3 3	2 3 3 3 6	5 8 9 9 9 3 4 7	6 6 7 7 8 0	7 8 2	0 0
	5 0 5	2 3 5 5 2 3 5 6 9 1	9 0 8 3 4 0 1 2 7	6 7 7 8 9 0 1 3	0 1 2 4 5 6 3	8 9 0 0 5 6 7	7 5 4 1 9 5 8	5 1 5 9 0 2 3	4 7 6 5 0 6	5 0 4	4 2 4 5 6	4 8 9	1 9 0 2 5 8	8 7 1 7 8 4 4 8	7 9 0 9 8 3	2 2 7	6 7
Alliance	I		II										III		IV		
Association	1	2	3	4.1	4.2	4.3	5	6	7	8	9	10.4	11.1	11.2	12.1	12.2	13
Species group R (cont.)																	
Oxalis semiloba	. . .	. . . .	. . . .	. . . .	. . . .	R + + . . + .	. . R . . . +	R . . 1 . . +	. . R R . .	. . R	. . . + 1	. . .	. . . . . .	. . . .	. . . . . .	R . .	. .
Chionanthus foveolatus	. . .	. . . .	. . . .	. . . .	. . . .	. . R . . . R	. + ... 1	. . . . R . .	R . . . . +	. R .	+ R 1 + .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Cymbopogon validus	. + .	. . . .	. . . .	. . . .	. . . + . . .	. . . . R . +	. . . . . 1 1	. 1 . 1 1 1 A	. . . . + .	. A .	1 . 1 1 B	. . .	. . . . . .	. . . .	. . . . . .	+ . .	. .
Species group S																	
Enteropogon macrostachys	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	1 A +	. . . . . .	. . . .	. . . . . .	. . .	. .
Cynodon dactylon	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	1 1 +	. . . . . .	. . . .	. . . . . .	. . .	. .
Eragrostis lehmanniana	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	1 + +	. . . . . .	. . . .	. . . . . .	. . .	. .
Panicum coloratum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	R + R	. . . . . .	. . . .	. . . . . .	. . .	. .
Psiadia punctulata	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	+ . +	. . . . . .	. . . .	. . . . . .	. . .	. .
Species group T																	
Elephantorrhiza praetermissa	. . .	. . . .	1 A R . + 1 . + +	. . + . . . R .	. 1 1 . . + .	. R R	. 1 + ...	. . . . . R .	R . + . . 1	+ + .	. . . . .	+ . .	R . . . R .	. . . . . R . .	. . . . . .	. . .	. .
Ruellia patula	. R R	. . + ...	+ 1 . . . . + . .	+ . . + . + . .	R . + . . . +	. . . R R . .	+ + + R + . .	. + 1	. . . . . +	. 1 R	+ . + + +	. + .	. . . . . .	. . . . + . . .	. . . . . .	. . .	. .
Cymbopogon excavatus	. . .	+ R . + . . + . . .	1 . 1 1 . + 1 . .	R . 1 + . + R +	1 . . . 1 . 1	+ R + 1 + R 1	+ . + + A . 1	1 . 1 + 1 1 +	. 1 + + 1 .	. 1 1	. + . + .	. R R	. R + . . .	. . . . + . . .	. . . . . .	. . .	. .
Asparagus laricinus	. . .	. . . . R . .	R R + R + R R R R	. R + . . R . .	R + R . . R .	+ R R R . . .	R R . . . R R	. . . R R R .	R R R . R .	. . .	. R R . .	. . R	. . . . . .	. . . .	. . . . . .	. . .	. .
Acacia caffra	. + .	. . . . + .	R . . R . . R . +	R R + . R + + .	. . . + R . +	+ R . + . . .	+ + . . + . .	R	1 . . . + +	. R .	+ + + . +	1 . +	. R . . . R	. . . .	. . . . . .	. . R	. .
Themeda triandra	. . .	. . . . + . R	. A . 3 . + A R R	1 1 1 . . + R A	1 A B 1 1 . 1	A 1 . A . + +	+ + 1 . 1 1 +	R + A . 1 . 1	A + 1 . R .	+ R .	. . + . .	+ . .	R . . . . +	. . . . R	. . . . . .	. . .	. .
Combretum molle	. . .	. + . . + . . . + .	. + R R . R + . +	+ . 1 + 1 + + +	1 1 1 1 + . .	+ 1 + . . + .	. . . R . . .	. . R + . . .	+ R R + . 1	. . .	. . . . .	+ + .	. . . . . .	. . . .	. . . . . .	. . .	. .
Olinia emarginata	+ . R	. . . .	. + . . + + . . .	. . . + R . . .	+ . . R . + .	+ . . + . + .	+ + . . . R .	. . . + . . .	. R . . + .	R . +	+ 1 + . .	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Pavetta zeyheri	. . .	. . . . R .	. . 1 + 1 . 1 + +	. R . . . + . .	+ + + . + + .	+ . . . + . .	. . + . . + +	. . R	. 1 + 1 R 1	. + +	. . . R .	. + R	. . . . . .	. . . .	. . . . . .	. . .	. .
Gerbera jamesonii	. . R	. R . . . . . + R .	. . . . + .	. . . + R . . .	. R R + 1 R .	+ + + 1 . R .	+ R . R . . .	+ + . + + + .	+	. . .	R . R . .	R . +	. . . . . .	. . R	. . . R R .	. . .	. .
Scolopia zeyheri	. . .	. . . .	. . . .	+ + . . 1 . . +	. + + + . . .	R . R	. + . + + + .	. + . + 1 + R	. + + + . R	. . .	+ . R . +	. . .	. . . . . .	. . . .	. . . . . .	. . .	. .
Ruellia stenophylla	. . .	. . . . R . .	. . . .	. . R 1 . . . +	+ + 1 . . R +	. . + . . . +	. . + R . . R	. R	. + ...	+ + +	+ R . + +	+ . .	. . . . . .	. . . . + . . .	. . . . . .	. . .	. .
Species group U																	
Euphorbia cooperi	. . .	. . . .	. . . .	. . . .	. . . .	+ + . + . . .	. . R	. + ...	. . . . . .	. . .	. . . . .	. . .	1 + + + + .	. . . .	. . . . . .	. . .	. .
Cheilanthes involuta	. . .	. . . .	. . . .	. . R . R . . .	. . . .	. . . .	+	. . . .	+	. . .	. . . . .	. . .	+ . . 1 R .	. . . .	. . . . . .	. . .	. .
Stylochaeton natalensis	. . .	. . R . . . . . . R	. . . . +	. . . .	. . . .	R	. . . .	. R	+	. . .	. . . . .	. . .	R 1 R + R .	. . R	. . . . . .	. . .	. .
Microchloa caffra	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	R . R . + +	. . . .	. . . . . .	. . .	. .
Vangueria infausta	. . .	. . . . + .	. . . . . . R . .	. . . .	. . . .	. . . .	. . . + . . .	. . . R . . .	. . . . . .	. . R	. . . . .	. R .	R . + + . +	. . . .	. . . . . .	. . .	. .
Aristida scabrivalvis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. + + . + R	. . . + ...	. . . . . .	. . .	. .
Orthosiphon amabilis	. . .	. . . .	. . . .	. . . . . . R .	. . . . . R .	. . . .	. . . .	R	. . . . . .	. . .	. . . . .	. . .	. R + R R +	. . . .	. . . . . .	. . .	. .
Dioscorea dregeana	. . .	. . . .	. . . .	. . . . R . . R	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. R . + . R	. . . .	. . . . . .	. . .	. .
Species group V																	
Xerophyta villosa	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . + .	1 + + + . 1 1 .	. . . . . .	. . .	. .
Crassula alba	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . R . . .	. . . .	. . . . . .	. . .	. . . R .	. . .	. . . . . .	1 R + . . + R .	. . . . . .	. . .	. .
Selaginella dregei	. . .	. . . .	. . . .	. . . .	. . . .	. . . . . + .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	+ . + . . R + +	. . . . . .	. . .	. .
Kleinia longiflora	. . .	. . . .	. . . .	. . . .	. . . R . . .	. . . .	R	. . . . . + .	+ . + . . .	. . +	. . . . .	. . .	. . . . . .	+ . . + + . + .	. . . . . .	. . .	. .
Thesium burkei	. . .	. . . .	. . R	. . . .	. . . . . . R	. . . . . . R	. . . R R . .	. . . .	. . . . . .	R . .	. . . . .	. . .	. . . . . .	R R . . R . R .	. . . . . .	. . .	. .
Euphorbia schinzii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	R . R . . R R .	. . . . . .	. . .	. .
Rhus wilmsii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . R + . .	 1	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. R + . 1 . R .	. . . . . .	. . .	. .
Ceterach cordatum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. R . R . + . +	. . . . . .	. . .	. .
Kalanchoe luciae	. . .	. . . . + .	. . . . . . + . .	. . . .	. . . .	. . . . . + .	. . . .	. . + . . R +	+	. . .	. . . . .	. . .	+	. R . + + . . +	. . . . . .	. . .	. .
Kedrostis foetidissima	. . .	. . . .	. . . . R .	. . . .	. . . .	R . R	. R R	. . . .	. R	. . .	. . . . .	. . .	. . . . . .	. R . R . + . R	. . . . . .	. . .	. .
Cheilanthes eckloniana	. . .	. . . . R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . 1 1 R . . R	. . . . . .	. . .	. .
Species group W																	
Eragrostis pseudosclerantha	. . .	. . . .	. . . .	+ R	. . + ...	R . R . . R .	. . . .	. . R	. R	. . .	. . . . .	. . .	1 + . 1 + +	1 . + . . + . +	. . . . . .	. . .	. .
Craterostigma wilmsii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	+ + 1 . . .	. R R . . + + +	. . . . . .	. . .	. .
Crassula swaziensis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	+ + + + 1 .	1 + . + . R + +	. . . . . .	. . .	. .
Myrothamnus flabellifolius	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	+ . R + + A	. R + + R . 1 +	. . . . . .	. . .	. .
Aristida adscensionis	. . .	. . + ... + .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	+ . . + . .	1 + . . + . 1 .	. . . . . .	. . .	. .
Eragrostis capensis	. . .	. . . .	. . . .	. . . .	. . . . R . .	. . . .	. . . .	. + ...	. . . . . .	. . .	R R . . .	. . .	+ . . . + .	. + 1 . + . R .	. . . . . .	. . .	. .
Melinis repens	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. + . + . . .	+	. + ...	. . .	R . . . +	. . .	R R R + 1 R	R R R R . R . R	. . . . . .	. . .	. .
Scilla natalensis	. . .	. . . .	. . . .	. . . .	. . . .	. . . . R . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	R . + . . .	+ . . . R . R .	. . . . . .	. . .	. .
Oldenlandia herbacea	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. + . . + 1	. + R + . + . +	. . . . . .	. . .	. .
Ursinia nana	. . .	. . . .	. R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. + + . + R	+ . . + . + . R	. . . . . .	. . .	. .
Pearsonia cajanifolia	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. R . R . +	. + . . R . . +	. . . . . .	. . .	. .

TABLE 1.—Phytosociological table of vegetation of rock habitats in Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé number	125 190 215	122 123 185 195 222 243 245 286 289 401	129 130 138 153 224 230 231 242 247	16 17 27 38 39 40 41 83	80 81 82 84 85 96 313	18 19 20 50 259 296 317	7 15 24 71 99 105 108	45 51 55 59 60 62 93	54 107 136 225 240 246	315 320 324	4 12 74 75 76	334 338 339	1 29 30 32 35 68	58 87 91 97 98 134 244 278	67 69 70 79 88 103	72 182 227	406 407
Alliance	I		II										III		IV		
Association	1	2	3	4.1	4.2	4.3	5	6	7	8	9	10.4	11.1	11.2	12.1	12.2	13
Species group X																	
Ledebauria revaluta	. . .	. . . . R .	. . . .	. . . .	. . . .	. . . . R . .	. R R R + + +	. . + ...	. . . . . .	. . .	. . . . .	. . .	+ . . . R +	+ + + R R + . +	. . . . . .	. . .	. .
Hypoxis rigidula	. . .	. . . .	. . . .	R R . . . . . +	. . . . . . +	. . . . . . +	. . + + + . +	. . . . . . +	. . . . . .	. . .	. . . . .	. . .	+ . . . . +	. . . R + . . .	. . . . . .	. . .	. .
Crassula sarcacaulis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	R . + R + . .	. . + . . . R	. . . . . .	. . .	. . R . .	. R .	. + + + . +	+ + + + + . 1 1	. . . . . .	. . .	. .
Lophalaena cariifolia	. . .	. . . .	. . . .	. . . .	. . . .	. . . . . R +	R . R + R . .	. . . .	. . . . . .	R . .	. . . . .	. . .	. + R R . +	+ R R R R + + +	. . . . . .	. . .	. .
Species group Y																	
Xerophyta retinervis	. . .	. . . .	1 + + . + + 1 + 1	R . . . R . . R	. . . .	R	. . + + . . +	1 + + ...	+ + + + + +	. . .	. . . . .	. . .	+ R + + + R	+ + R R + + + +	. . . . . .	. . .	. .
Sphedamnocarpus pruriens	. . .	. . . .	+ R R + + . . . R	. . R + . . R .	. + . . . R .	. . . .	. 1 1 . 1 . .	. + ...	1 R + + R R	. . +	. . . . .	. . .	+ . . . . +	+ . . . + . . R	. . . . . .	. . .	. .
Mundulea sericea	. . .	. . . .	+ . . + . R . . +	. R + . . R . .	. . . .	. . . .	. + + ...	. . . . . R .	. . + + . .	+ . .	. . . . .	. . .	+ + + + + .	+ . + . + + + .	. . . . . .	. . .	. .
Raphianacme galpinii	. . .	. . . .	R . . + R R . R R	R R . . . . . R	. R R	R R R R . R .	R R . R . R R	R	. R . R R R	. . .	. . . . .	. . .	+ . . R . R	R R R R R . R R	. . . . . .	. . .	. .
Tristachya leucothrix	. . .	. . . .	+	. . . + . . . +	. . . .	. R . . . . R	. . + A . . .	. . . 1 + + .	1 . . . . +	+ . .	. . . . .	. . .	+ 1 + . . .	. . . + ...	. . . . . .	. . .	. .
Senecio latifalius	. . .	. . . .	. . + ... +	R . R . . + . .	+ R + + . + 1	. . . R . + +	R + R R R + +	. R . . . + +	+ R + + . +	+ + R	. . . . .	. . .	1 R . R R .	R . . . 1 R . .	. . . . . .	. . .	. .
Melinis nerviglumis	. . .	+ . . . . . + . . .	. . . . R . . . +	1 + + . R . + +	. . . .	. + . . . + .	. + + + 1 . .	. + . 1 . . .	. 1 1 A . .	R . .	. . . . .	. . .	. . + . . +	. A + + A + . 1	. . . . . .	. . .	. .
Setaria sphacelata	. . .	. . . .	. . . . . . + . .	B 1 + 1 . A 1 1	A 1 1 A 1 . +	. . R . R . .	+ 1 + 1 1 . .	. . . . + . .	. . + . 1 .	. . 1	. . . . .	. . .	+ R R R R .	. . . . + . . .	. . . . . .	. . .	. .
Species group Z																	
Aristida transvaalensis	+ . .	. . . . + . +	1 . . . 1 1 1 1 +	. R . . . R . .	. . . R . . .	. . + . . . 1	+ . 1 . . + .	. . 1 + 1 + .	. + 1 + . .	. . R	. + 1 B R	+ . R	1 A . + . 1	1 1 A + A + 1 1	. . . . . .	+ . .	. .
Pellaea calamelanas	R R .	. R . . . + . . + .	+ R R + R + R + +	. . . . R . . +	. + R . . . R	R . R . + . R	+ . R R . . .	+ + ...	+ R . . . R	. R .	R . R . .	. . .	. R + + R R	+ + R + + R . R	. . . . . .	. . .	. .
Alae castanea	R . .	. . . . R	+ . . . . + . . .	R . R + + . . R	R + R . . R .	+ + 1 + + 1 1	1 + + 1 + . +	+ 1 + . . + +	1 1 . . . R	R . .	+ R R . R	. R .	1 R 1 . + .	R + + + + R R +	. . . . . .	. . .	. .
Commelina africana	R . R	R . . . + R + R . .	+ + . + + R + . R	+ A . . R R . +	R R R . . . R	+ . . R . + .	. . + R . . .	+ . + R . + .	1 1 . . R +	1 . .	+ . R R R	. . .	+ R + R R .	. . . R . . R .	. . . . . .	. . .	. .
Vitex obovata subsp. *wilmsii*	. R .	. . . .	. . + . . . + . .	R R R R . + R R	R + R + + . +	R R . . . R .	A + 1 + A + +	. . R + + 1 +	+ + 1 + . .	. . .	. 1 . R R	R . R	1 R + . . R	. R . . . R . R	. . . . . .	R . .	. .
Eragrastis racemosa	. . R	. R	. R . R	. R . + . . . R	. + . . R . +	. . . R . + +	. . . . . R R	. R . . + . .	. . R . R .	. R .	. 1 + + .	. + .	+ + 1 1 + A	+ . + . . + . +	. . . . . .	. . .	. .
Heteropogan cantartus	. . .	. . R R . . . 1 . .	. . . . + . . . 1	. . + . + . . .	1 1 1 . . . 1	. + . . . R +	. . + R . . .	+ . B R . . +	+ . . . + .	. . 1	. + + + .	A R +	. 1 + + 1 +	. R . . . . R .	. . . . . .	. . .	. .
Cyphastemma waodii	. . .	+ . . . R . + . . .	R + . . + R . R .	R R . R + . . R	. R R R R R R	+ R + R R . .	. . . . R . R	R R R + R . .	. . R R . .	. R R	R R . R R	. . .	. R R R R .	. . . . R . . R	. . . . . .	. . .	. .
Species group AA																	
Clausena anisata	. . .	. . . .	. . . .	. . . .	. . . + R + .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	A + 1 + + +	. . .	. .
Urochlaa masambicensis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	1 . R . + +	. . .	. .
Cyathula cylindrica	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ 1 1 R . 1	. . .	. .
Obetia tenax	. . .	. . . . +	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ 1 R + . .	. . .	. .
Abutilan austra-africanum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ + R + + .	. . .	. .
Clerodendrum myricoides	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ + R + . +	. . .	. .
Setaria verticillata	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ + R R . R	. . .	. .
Clerodendrum glabrum	. . .	. . . .	. . . .	. . . . + + . +	. + + . 1 + .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ R 1 1 1 .	. . .	. .
Ficus thanningii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	+ . + . .	. . .	. . . . . .	. . . .	+ R R R . +	. . .	. .
Hermannia floribunda	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	+ . + + . .	. . .	. .
Alae marlothii	. . .	. . . . + . .	. . . + ...	. . . .	. . . .	. . . . . + +	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . + R	. . . .	R 1 R + . .	. . .	. .
Plectranthus laxiflorus	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	R R + . + .	. . .	. .
Senecio macrocephalus	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	R R R + R .	. . .	. .
Scadaxus puniceus	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . R . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	R . + . + .	. . .	. .
Brachiaria brizantha	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. + . . R +	. . .	. .
Digitaria sanguinalis	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. R 1 . + R	. . .	. .
Species group AB																	
Ficus sur	+ . +	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . +	. . .	. . . . . .	. . . .	. + . . . +	1 A +	. .
Cambretum erythrophyllum	+ + .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. + + . +	. . .	. . . . . .	. . . .	. . . . . .	1 1 +	. .
Acacia galpinii	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	+ 1 R	. .
Spirastachys africana	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	+ 1 R	. .
Barleria obtusa	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	+ . 1	. .
Secamane acutifalia	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	R + +	R .
Melia azedarach	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	R + R	. .
Cardiaspermum carindum	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	R + .	. .
Achyranthes aspera	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. R R	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. 1 +	. .
Flueggea virosa	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . . .	. . .	. . . . .	. . .	. . . . . .	. . . .	. . . . . .	. + 1	. .

TABLE 1.—Phytosociological table of vegetation of rock habitats in Sekhukhuneland Centre of Plant Endemism (cont.)

Relevé number	125	190	215	122	123	185	195	222	243	245	286	289	401	129	130	138	153	224	230	231	242	247	16	17	27	38	39	40	41	83	80	81	82	84	85	96	313	18	19	20	50	295	296	317	7	15	24	71	99	105	108	45	51	55	59	60	62	93	54	107	136	225	240	246	315	320	324	4	12	74	75	76	334	338	339	1	29	30	32	35	68	58	87	91	97	98	134	244	278	67	69	70	79	88	103	72	182	227	406	407
Alliance	I													II																																																														III														IV										
Association	1			2										3									4.1								4.2							4.3							5							6							7						8			9					10.4			11.1						11.2								12.1						12.2			13	
Species group AC																																																																																																					
Pavonia burchellii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	R	+	R	R	.	+	R	.	.
Lippia javanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	R	R	.	.	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	R	+	+	R	.	+	+	R	.	.
Acacia nigrescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	A	.	R	+	.	+		.	R
Pavetta gardeniifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	R	+	R	+	.	.	.
Ehretia rigida	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		+	R	+	.	R	.	+	+	R	.
Panicum maximum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	1	.	1	1	.	R
Schotia brachypetala	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	+	.	R	R	1	.	.	.
Species group AD																																																																																																					
Andrachne ovalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1
Allophylus transvaalensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	+	+
Carissa bispinosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	+	+
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Maytenus undata	+	1	+	+	+	+	+	+	.	+	1	+	.	.	.	+	+	+	R	+	.	+	.	.	+	+	+	R	R	.	R	R	.	+	+	+	.	+	.	+	+	.	.	.	.	.	+	+	.	.	+	+	.	+	.	.	+	+	.	+	.	+	.	.	.	+	.	.	R	+	+	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	R	R	R	.	.	R	R	R
Sarcostemma viminale	+	.	.	R	.	+	.	R	R	.	1	.	.	.	.	.	.	.	.	.	+	R	.	+	.	.	1	+	.	.	.	.	.	R	+	.	.	R	+	+	.	.	.	.	1	+	.	R	.	.	.	+	+	R	.	.	+	.	R	R	.	.	.	.	.	.	R	R	.	R	R	.	.	.	.	R	.	.	.	.	+	.	R	R	+	.	R	.	+	.	.	.	R	.	+	.	.	.	.	.
Pappea capensis	+	+	+	.	.	.	R	.	.	.	.	.	+	.	R	+	R	R	R	R	R	.	.	.	.	R	R	.	.	R	.	.	.	.	R	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	R	+	+	.	.	.	.	.	R	+	.	.	R	.	.	.	.	R	.	.	+	R	.	.	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	R	.	+	R	R	.	.	.	.	.
Euclea crispa	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	R	1	1	+	1	+	.	+	+	+	+	R	1	+	.	.	.	R	+	.	R	1	.	+	R	1	+	+	.	.	+	+	1	+	.	.	.	+	+	.	+	1	1	1	+	R	.	+	.	+	1	+	+	R	R	R	+	R	.	+	.	.	+	.	.	.	.	.	.	+	1	+	+	.	.	.	.
Hippobromus pauciflorus	R	R	1	.	.	.	R	.	+	+	1	.	.	R	+	R	+	.	+	1	1	+	1	1	1	1	+	+	1	+	1	1	+	+	1	+	+	1	+	1	1	R	.	.	1	1	1	+	+	1	+	.	1	+	.	R	.	.	+	1	1	1	R	1	+	.	.	R	R	+	R	1	1	B	1	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	+	.	1	1	.	R	.	+	.	R
Acacia ataxacantha	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	1	A	+	+	1	1	+	R	+	+	+	R	R	1	.	.	.	.	R	.	.	.	+	+	+	+	.	+	R	.	R	.	.	.	.	.	R	+	+	.	.	.	.	.	.	R	+	.	+	+	.	.	.	.	.	.	.	.	R	.	.	R	.	.	.	.	.	1	1	+	1	R	1	+	R	.	.	.
Berkheya zeyheri	.	+	R	.	.	.	.	.	.	.	.	.	.	+	.	.	.	R	.	R	.	.	+	.	+	.	.	R	.	.	+	+	.	R	.	.	.	.	.	.	.	.	.	.	+	.	R	.	.	.	R	.	.	.	.	.	.	.	R	.	.	R	+	R	.	.	.	.	.	R	R	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	R	.	.	.	R	R	.	.	.
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Ziziphus mucronata	.	R	.	.	.	.	.	.	.	R	.	.	.	.	+	.	R	R	+	.	.	.	+	+	1	1	.	1	1	R	+	.	R	.	+	.	.	.	1	1	.	R	.	R	+	1	1	R	+	+	+	.	.	1	+	1	1	+	.	.	.	R	.	.	+	.	.	.	.	.	.	R	.	.	.	.	.	R	.	.	.	.	.	.	R	R	.	.	.	+	+	+	+	.	R	.	R	+	.	.
Cassine aethiopica	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	R	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	+	.	.	.	.	.	.	R	.	.	.	.	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	+	R	.	.
Zanthoxylum thorncroftii	.	.	R	.	.	.	.	.	.	.	R	.	.	.	+	+	+	.	+	+	.	.	.	.	.	+	1	1	+	.	R	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	+	.	+	.	.	+	.	.	.	.	.	.	R	.	R	.	.	.	.	R	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	+	.	1	+	.	+	.	.	+	.	.
Rhus leptodictya	.	.	R	.	.	+	.	.	R	.	.	.	.	+	.	+	+	.	.	.	+	.	+	R	R	R	+	.	+	.	.	+	+	+	R	+	.	.	.	.	.	R	.	.	+	.	R	R	.	+	+	R	1	R	.	.	.	.	+	.	.	.	R	+	+	.	.	R	+	.	+	R	.	.	.	+	R	R	.	.	R	.	.	.	.	R	.	.	R	R	R	R	R	.	+	+	.	.	.	.
Rhoicissus tridentata	.	.	.	R	.	R	.	R	.	.	.	.	.	+	.	1	.	+	+	.	1	.	.	.	+	+	+	.	.	+	+	.	1	+	1	1	+	+	+	.	+	+	+	.	1	+	1	R	1	+	1	.	.	+	+	+	.	1	+	+	+	+	+	+	1	A	A	.	.	.	R	R	1	+	R	+	R	+	R	R	.	.	.	.	.	1	.	R	.	A	.	+	R	1	R	R	.	.	.	.

local differentiation of the plant communities. Plant communities relate to soil type, rockiness and terrain type, with aspect and slope also of importance. The four major communities (potential alliances) are distinctive and easily distinguishable in the field. This might be attributed to the uniformity of the environmental factors for each of the major communities, causing a distinct distribution pattern of habitats and associated vegetation.

The hierarchical classification of the vegetation is reinforced by the correlation between habitat and plant communities (Figure 2). The distribution of Sekhukhuneland Centre endemic/near-endemic and Red Data List taxa among various plant communities is listed in Table 2. A summary of selected community attributes is supplied in Table 3. Plant communities of the *Hippobromus pauciflorus–Rhoicissus tridentata* Rock Outcrop Vegetation recognized in the SCPE are classified as follows:

Four types of rock habitats are recognized for the region, namely rocky outcrops (I), rocky ridges (II), rocky flats (III) and rocky refugia (IV). Rocky outcrops are defined as a mass of exposed stacked boulders on hills. Rocky ridges are defined as exposed reefs and scattered groups of rocks and boulders on the sides of mountains/hills. Rocky flats are defined as rock beds exposed at ground level. Rocky refugia are defined as sheltered rocky areas of scattered boulders around caves, in kloofs and below cliffs.

I. *Setario lindenbergianae–Crotion gratissimi* Alliance of Rocky Outcrops
1. *Vepro reflexae–Mimusopetum zeyheri* Association
2. *Setario lindenbergianae–Crotonetum gratissimi* Association

II. *Themedo triandrae–Combretion mollis* Alliance of Rocky Ridges
3. *Grewio monticolae–Elephantorrhizetum praetermissae* Association
4. *Setario lindenbergianae–Combretetum mollis* Association
4.1. *Setario lindenbergianae–Combretetum mollis cathetosum edulis* Subassociation
4.2. *Setario lindenbergianae–Combretetum mollis diospyretosum nitensis* Subassociation
4.3. *Setario lindenbergianae–Combretetum mollis aloetum aculeatae* Subassociation
5. *Brachiario serratae–Viticetum wilmsii* Association
6. *Cymbopogono validi–Brachylaenetum rotundatae* Association
7. *Aloo pretoriensis–Xerophytetum retinervis* Association
8. *Tephrosio purpureae–Rhoicissetum tridentatae* Association
9. *Sporobolo fimbriati–Rhamnetum prinoidis* Association
10. *Eragrostio lehmannianae–Hippobrometum pauciflori* Association
10.4. *Eragrostio lehmannianae–Hippobrometum pauciflori enteropogono macrostachyos* Subassociation

III. *Ursinio nanae–Myrothamnion flabellifoli* Alliance of Rocky Flats
11. *Ursinio nanae–Myrothamnetum flabellifoli* Association
11.1. *Ursinio nanae–Myrothamnetum flabellifoli euphorbietosum cooperi* Subassociation
11.2. *Ursinio nanae–Myrothamnetum flabellifoli xerophytosum villosae* Subassociation

IV. *Combreto erythrophylli–Celtion africanae* Alliance of Rocky Refugia
12. *Acacio ataxacanthae–Celtidetum africanae* Association
12.1. *Acacio ataxacanthae–Celtidetum africanae clausenetosum anisatae* Subassociation
12.2. *Acacio ataxacanthae–Celtidetum africanae acacietosum galpinii* Subassociation
13. *Andrachno ovalis–Allophylletum transvaalensis* Association

Plant community descriptions

The *Hippobromus pauciflorus-Rhoicissus tridentata* Rock Outcrop Vegetation is largely restricted to the slopes and plateaus of undulating ultramafic hills. Surface rocks are predominant and abundant in these habitats, with rock percentage varying from 25% on the rocky flats to more than 50% in the rocky refugia. The vegetation can structurally be classified into forest/woodland (rocky refugia), woodland/thicket (rocky outcrops and ridges) and herbland (rocky flats) (Edwards 1983). The rock habitats of Sekhukhuneland, like those in other parts of the world (Madulid & Agoo 1995), constitute an important feature which occurs in islands differing significantly from surrounding areas.

I. *Setario lindenbergianae–Crotion gratissimi* all. nova hoc loco

Nomenclatural type: *Setario lindenbergianae–Crotonetum gratissimi* (holotypus), Association 2 described in this paper. This proposed alliance is floristically related to the *Croton gratissimus–Setaria lindenbergiana* Woodland of Van der Meulen (1979).

Species group D (Table 1).

Environmental data: the vegetation of this alliance of rocky outcrops is a thicket or woodland. It is found on all aspects of gently sloped (1–5°) rock intrusions on midslopes, scarps and occasionally in valleys (Table 3). Soil forms are shallow and rocky. The soil surface is covered by 60–90% of rock with a large average diameter of 2.5–8 m (Table 3).

Diagnostic taxa: the trees *Ficus abutilifolia*, *Homalium dentatum*, *Pouzolzia mixta* and *Vepris reflexa* and the herbaceous shrubby climbers *Asparagus buchananii*, *A. intricatus* and *Rhoicissus sekhukhuniensis*.

Dominant/prominent taxa: trees are *Croton gratissimus* and *Maytenus undata*, the dominant grass is *Panicum deustum* and frequently occurring herbaceous taxa include the forb *Commelina africana*, the fern *Pellaea calomelanos* and the succulent *Sarcostemma viminale*.

Notes on floristic diversity: floristic links with the rest of the data set are visible in species groups K, Z and AG (Table 1). These few and weak links support the proposal of this major group as an alliance. The mean number of species encountered per sample plot in this group is 29, with a total number of 107 plant taxa (13 relevés) (Table 3). There are 16 plant taxa of conservation value, ten are SCPE endemics and six are SCPE near-endemics. One of the endemics, *Euphorbia sekukuniensis*, is a Red Data List taxon assessed as Rare (Table 2). Eight endemics of conservation value are restricted to this community of the SCPE.

TABLE 2.—Endemic/near-endemic and Red Data List plant taxa of rock habitats of Sekhukhuneland Centre of Plant Endemism

Species	Family	Syntaxa																
		I		II									III		IV		
		1	2	3	4.1	4.2	4.3	5	6	7	8	9	10.4	11.1	11.2	12.1	12.2	13
Adenia wilmsii	PASS		K ne r															
Aloe castanea	ASPH	ne r	ne r	ne f	ne f	ne r	ne a	ne a	ne a	ne f	ne r	ne r	ne r	ne a	ne f			
Aloe reitzii var. *reitzii*	ASPH						I ne r											
Asparagus intricatus	LILI	ne f	ne f	ne r														
Asparagus sekukuniensis	LILI		K e r															
Berkheya insignis (form), *Siebert 257*	ASTE					e r												
Catha transvaalensis	CELA						e a	e a	e a	e r	e r	e f	c r					
Chlorophytum cyperaceum	LILI						ne r											
Cyphostemma sp. nov. A, *Van Wyk 13389*	VITA		e r				e f	e r	e r		e r							
Cyphostemma sp. nov. B, *Siebert 1383*	VITA		e r		e r		e f			e r						e r		
Elephantorrhiza praetermissa	FABA			K e a	K e r	K e f	K e r	K e f	K e r	K e f	K e f		K e r	K e r	K e r			
Eucomis montana	LILI					R r												
Euphorbia lydenburgensis	EUPH			ne f												ne r		
Euphorbia sekukuniensis	EUPH		R e a															
Gnidia caffra (form), *Van Wyk 12975*	TILI					e f												
Gymnosporia sp. nov. A, *Van Wyk 13351*	CELA																	ne f
Gymnosporia sp. nov. B, *Siebert 458*	CELA				e f												e f	
Helichrysum albilanatum	ASTE										ne r							
Huernia insigniflora	ASCL		ne r											ne r				
Jasminum quinatum	OLEA				ne r	ne f		ne r			ne r							
Jatropha latifolia var. *latifolia*	EUPH			ne r						ne f								
Kleinia longiflora (form), *Van Wyk 13239*	ASTE							e f										
Kleinia stapeliiformis	ASTE	ne r		ne f					ne r		ne r							
Orthosiphon fruticosus	LAMI			e f						e r	e r							
Pavetta zeyheri (form), *Siebert 22*	RUBI		e r	e a	e r	e f	e r	e f	e r	e a	e f	e r	e r					
Plectranthus venterii	LAMI		e f															
Plectranthus xerophilus	LAMI						ne f											
Premna mooiensis (form), *Van Wyk 13004*	VERB		e a															
Rhoicissus sekhukhuniensis	VITA	e a	e a															
Rhoicissus sp. nov., *Siebert 48*	VITA										e a				e r			
Rhus rogersii	ANAC						N r			N r				N r				
Rhus sekhukhuniensis	ANAC										R e r							
Rhus wilmsii	ANAC							Kne f	Kne f						Kne a			
Scilla natalensis	LILI						N r							N r	N f			
Solanum incanum (form), *Van Wyk 13013*	SOLA		e f															
Stylochaeton sp. nov., *Siebert 1845*	ARAC		e f															
Triaspis glaucophylla	MALP			ne r	ne r	ne a		ne r						ne r	ne r			
Tulbaghia coddii	LILI									K ne r	K ne r			K ne r				
Vitex obovata subsp. *wilmsii*	VERB	ne r		ne f	ne f	ne f	ne r	ne a	ne a	ne a		ne f	ne r	ne f	ne r		ne r	
Xerophyta retinervis (form), *Van Wyk 13208*	VELL			e a	e r		e r	e f	e f	e a				e f	e f			
Zantedeschia pentlandii	ARAC				Rne f	Rne r	Rne a	Rne f	Rne f	Rne r	Rne r			Rne r	Rne r			
SCPE endemics (subassociations)					5	4	6							2	3	1	I	
SCPE endemics (associations)		I	10	4		9		6	5	6	7	2	3	3		2		0
SCPE near-endemics (subassociations)					5	5	6							6	5	1	1	
SCPE near-endemics (associations)		4	4	7		8		6	5	5	6	2	2	7		2		1
Red Data List taxa (subassociations)					2	3	5							5	4	0	0	
Red Data List taxa (associations)		0	3	1		6		3	3	4	4	0	1	6		0		0
Restricted to subassociations					0	3	3							0	0	0	0	
Restricted to association		0	7	0		6		1	0	0	2	0	0	0		0		1
Total for association		5	14	11		20		12	10	12	13	4	5	12		4		1

Endemism: e, endemic; ne, near-endemic. Red Data List: I, Indeterminate; K, Insufficiently Known; R, Rare; N, threatened, but not in the northern provinces. Abundance in communities: a, abundant; f, frequent; r, rare. Blocks represent taxa restricted to a specific syntaxon.

TABLE 3.—Environmental factors and selected attributes associated with different plant communities

Major vegetation unit	I		II										III		IV		
Association	1	2	3	4.1	4.2	4.3	5	6	7	8	9	10.4	11.1	11.2	12.1	12.2	13
Total number of species	46	91	89	105	110	103	109	109	89	75	64	35	66	75	68	64	65
Number of relevés	3	10	9	8	7	7	7	7	6	3	5	3	6	8	6	3	2
Mean number of species per relevé	31	27	30	46	46	39	40	34	33	34	34	20	30	27	41	33	35
Number of endemics/near-endemics	5	14	11	10	9	12	12	10	11	13	4	5	8	8	2	2	1
Number of Red Data List taxa	0	3	1	2	3	5	3	3	4	4	0	1	5	4	0	0	0
Geology	H	N/P	N/P	N	N	N	Ma/N	Fe/N	N/P	N/P	H	N	N	N/P	N	A/N	N
Topographic position	M/S	M/S	M/S	M/S	M/S	M/S	M/S	M/S	M/S	M/S	M/F	M/S	F/M/S	F/M/S	F/M	V	C
Slope (°)	1–3	0–1	3–7	5–15	3–15	1–3	3–7	1–5	1–5	1–3	1–3	3–9	1–3	3–9	3–7	3–5	1–3
Aspect	-	-	NE	N	S	-	NESW	NESW	SE	SW	-	SE	NSW	NESW	ESW	-	S
Predominant soil type	Bo	Ms	Gs*/Ms	My*/Mw	My*/Mw	Ms	Ms/Mw	Ms*/My	Gs/Ms	Mw/My	Sand	Sand	Sand	Sand	My*/Oa	My*/Oa	Oa
Rock cover percentage (%)	70–80	60–90	70–90	45–50	45–60	70–80	50–60	60–80	60–80	50–70	60–70	20–40	70–80	60–90	10–40	20–70	20–40
Mean rock size (mm)	5500–7000	2500–8000	2000–4500	500–1000	500–1000	4000–7000	2500–3000	3000–5000	2500–3500	1000–3500	3500–5500	>500	> 10000	> 10000	1000–1500	500–1500	500–750

A, alluvium; Bo, Bonheim; C, crest; F, footslope; Fe, ferrogabbro; Gs, Glenrosa; H, harzburgite; M, midslope; Ma, magnetite; Ms, Mispah; Mw, Milkwood; My, Mayo; N, norite; Oa, Oakleaf; P, pyroxenite; S, scarp; V, valley.
*Dominant soil type.

1. *Vepro reflexae–Mimusopetum zeyheri* ass. nova hoc loco

Nomenclatural type: relevé 190 (holotypus).

Species group A (Table 1).

Related to the *Ilex mitis–Pittosporum viridiflorum* Forest (Coetzee 1975).

Environmental data: the vegetation is a sparse, tall thicket of rock outcrops on the banks of seasonal streams and rivers. It is mostly found along watercourses that flow from the mountains towards the valley of the Steelpoort River. The habitat has gentle, sloped sides (1–3°) (Table 3). The dominant soil type is the Bonheim Form, a melanic A-horizon underlain with a pedocutanic B. Mean rock size varies from 5.5 to 7 m in diameter and covers 70–80% of the soil surface.

Diagnostic taxa: the woody species *Heteropyxis natalensis*, *Mimusops zeyheri* and *Pittosporum viridiflorum* and the climbers *Abrus laevigatus*, *Rhoicissus tomentosa* and *Secamone filiformis*; there are no diagnostic grasses.

Dominant/prominent taxa: dominant woody species include *Ficus abutilifolia* and *Vepris reflexa*. *Cymbopogon validus* and *Panicum deustum* are common grass species; prominent forbs are *Orthosiphon labiatus* and *Ruellia patula*.

Notes on floristic diversity: this community is rare in the SCPE, and exhibits a slight floristic affinity with other rock habitats of the SCPE in species groups K and Z (Table 1). The mean number of species per relevé is 31, and the total number of species recorded for the association is 46 (three relevés) (Table 3). Five plant taxa of conservation value occur (Table 2), namely one SCPE endemic, *Rhoicissus sekhukhuniensis*, and four SCPE near-endemics.

2. *Setario lindenbergianae–Crotonetum gratissimi* ass. nova hoc loco

Nomenclatural type: relevé 195 (holotypus).

Species group B (Table 1).

Related to the *Croton gratissimus–Setaria lindenbergiana* Woodland (Van der Meulen 1979).

Environmental data: the vegetation is a sparse, short thicket on rocky outcrops in the Steelpoort River Valley. The plant community is associated with exposed norite or pyroxenite outcrops on level to gently sloped (0–1°) midslopes and scarps of hills. Surface rock cover percentage is 60–90%, with the stacked exposed boulders reaching diameters between 2.5 and 8 m (Table 3). The dominant soil type is the Mispah Form, indicating very shallow soils over rock.

Diagnostic taxa: trees/shrubs include *Commiphora marlothii*, *Euphorbia sekukuniensis*, *Nuxia congesta*, *Premna mooiensis* and *Steganotaenia araliacea*; woody forbs are *Abutilon pycnodon*, *Ruttya ovata* and *Turraea obtusifolia*, and the succulents *Cyphostemma sulcatum* and *Tetradenia brevispicata*; *Stylochaeton* sp. nov. (*Siebert 1332*) is an undescribed taxon and a neo-endemic of the SCPE.

Dominant/prominent taxa: *Andropogon schirensis*, *Cymbopogon excavatus*, *Eragrostis nindensis* and *Panicum deustum* are the dominant grasses; other prominent plants are the woody species *Barleria rotundifolia*, *Combretum molle*, *Croton gratissimus* and *Maytenus undata*.

Notes on floristic diversity: this plant community exhibits a slight floristic link with the rocky ridges of the Centre in species groups K, T and Z (Table 1). The mean number of species encountered per sample plot is 27, with the total number for this association being 91 (10 relevés) (Table 3). A high number of fourteen taxa with conservation status are recorded for the association (Table 2). Ten are SCPE endemics, which is the highest number recorded for any plant community of rock habitats in the SCPE. Four are SCPE near-endemics. Three Red Data List taxa are recorded. Of all the rock habitats, this association has the highest number of plant taxa with conservation value restricted to it (seven).

II. *Themedo triandrae–Combretion mollis* all. nova hoc loco

Nomenclatural type: *Setario lindenbergianae–Combretetum mollis* (holotypus), Association 4 described in this paper. This proposed alliance is floristically related to the *Combretum molle–Diheteropogon amplectens* Woodland Order of Van der Meulen (1979).

Species group T (Table 1).

Environmental data: in the SCPE this alliance of rocky ridges is characterized as open to closed moist bush clumps, with predominantly shallow, black and red clay soil forms. This vegetation occurs on midslopes and scarps of undulating ultramafic hills, on varying slopes of 1–15° on all aspects. Rocks cover 45–80% of the soil surface and vary in diameter from 1 to 5 m (Table 3).

Diagnostic taxa: the trees *Acacia caffra*, *Olinia emarginata* and *Scolopia zeyheri*, the shrubs *Elephantorrhiza praetermissa* and *Pavetta zeyheri*, the forbs *Ruellia patula* and *R. stenophylla*; the grass *Cymbopogon excavatus*.

Dominant/prominent taxa: other prominent species of the alliance include the trees *Combretum molle*, *Cussonia transvaalensis*, *Euclea crispa* and *Hippobromus pauciflorus*, and the ground layer is dominated by the grasses *Themeda triandra* and *Setaria sphacelata*.

Notes on floristic diversity: this major group is dominant and floristic relationships exist with all the other plant communities of rock habitats, indicating that it forms the core of this vegetation type in the SCPE (Table 1). Associations 4 to 9 represent bush clumps in the *Brachiario serratae–Melhanietum randii* Rocky Grassland of the Roossenekal Subcentre (Siebert *et al.* 2002d) and Associations 3, 5 and 10 represent bush clumps in the *Loudetio simplicis–Encleion linearis* and *Setario sphacelatae–Acacietum caffrae* of the Steelpoort Subcentre (Siebert *et al.* 2002b). The mean number of species encountered per sample plot is ± 35, and the total number of plant species is 150 taxa (62 relevés) (Table 3). Thirty-one taxa of conservation value are part of the proposed alliance, and 13 are restricted to it (Table 2). Thirteen SCPE endemics and 15 SCPE near-endemics were recorded. Nine taxa are listed on the Red Data List.

3. *Grewio monticolae–Elephantorrhizetum praetermissae* ass. nova hoc loco

Nomenclatural type: relevé 130 (holotypus).

Species group E (Table 1).

Environmental data: this association represents bush clumps on rocky ridges on warm north and northeast aspects of norite and pyroxenite hills in the Steelpoort Subcentre. It occurs on midslopes and scarps on red loam soils of the Glenrosa and Mispah Forms. It covers gentle to moderate sloped areas (3–7°). Rock cover on the surface is 70–90%, with rocks reaching 2–4.5 m in diameter (Table 3).

Diagnostic taxa: herbaceous taxa include forbs such as the herbs *Aspilia mossambicensis* and *Orthosiphon fruticosus* and the succulent *Kleinia stapeliiformis*; grasses are *Aristida rhiniochloa* and *Sporobolus stapfianus*; woody species are *Englerophytum magalismontanum* and *Grewia monticola*.

Dominant/prominent taxa: important dominant taxa are shrubs, namely *Elephantorrhiza praetermissa*, *Hippobromus pauciflorus*, *Pavetta zeyheri* and *Xerophyta retinervis* (form); grasses such as *Aristida transvaalensis*, *Panicum deustum* and *Themeda triandra* are dominant.

Notes on floristic diversity: this association is not strongly linked with the other associations of its group and is probably more related to the *Englerophytum magalismontanum–Acacia caffra* Mountain Bushveld (Winterbach *et al.* 2000). The mean number of species encountered per sample plot is 30, with a total number of 89 plant taxa (nine relevés) (Table 3). Four SCPE endemics, seven SCPE near-endemics and one Red Data List taxon are present in this association (Table 2). None of the 11 taxa of conservation value are restricted to it.

4. *Setario lindenbergianae–Combretetum mollis* ass. nova hoc loco

Nomenclatural type: relevé 41 (holotypus).

Species group J (Table 1).

Related to the *Setaria lindenbergiana–Combretum molle* Woodland Community (Bredenkamp *et al.* 1994).

Environmental data: this association represents bush clumps on moderate to steep-sloped (1–15°) midslopes and scarps of norite (sometimes pyroxenite) hills. It occurs on deeper red and black clay soils of the Mayo and Milkwood Forms, which are interspersed with shallow gravel soils of the Glenrosa Form. Rock cover is 45–80% of the soil surface with sizes between 0.5 and 7 m in diameter (Table 3).

Diagnostic taxa: herbaceous taxa include forbs such as the herbs *Commelina benghalensis* and *Orthosiphon labiatus* and the succulent *Tetradenia riparia*; the grass is *Eragrostis chloromelas*; woody species are *Cussonia paniculata*, *Dombeya rotundifolia*, *Ficus ingens*, *Grewia occidentalis* and *Seemannaralia gerrardii*.

Dominant/prominent taxa: important dominant taxa are trees, namely *Allophyllus africanus*, *Apodytes dimidiata*, *Croton gratissimus*, *Combretum molle* and *Cussonia transvaalensis*; grasses such as *Cymbopogon excavatus*, *Setaria lindenbergiana*, *S. sphacelata* and *Themeda triandra* are dominant.

Notes on floristic diversity: the association has a species combination typical for rocky outcrops in species group K, shared with Associations 1, 2 and 3 (Table 1). In species group P it shares a species combination typical of rocky ridges with Association 5 to 8 (Table 1). This community is also unique in that it shares forest species with Associations 12 and 13 in species group AF (Table 1). The mean number of species encountered per sample plot is ± 44, the highest mean number recorded per relevé for any of the major vegetation units of rock habitats in the SCPE. A total number of 122 plant taxa were recorded (22 relevés) (Table 3) of which 20 have conservation status (the highest number for any association of SCPE rocky habitats). Nine SCPE endemics, eight near-endemics (the highest number for rocky habitats) and six Red Data List taxa (the highest number for rocky habitats) are recorded for this association (Table 2). A high number of six taxa is restricted to it.

4.1. *Setario lindenbergianae–Combretetum mollis cathetosum edulis* subass. nova hoc loco

Nomenclatural type: relevé 41 (holotypus).

Species group F (Table 1).

Environmental data: this sub-association represents dry, warm bush clumps on northern aspects of hills. It occurs on deeper red and black clay soils of the Mayo and Milkwood Forms and lies on moderately sloped (5–15°) midslopes and scarps. Rock cover on the surface is 45–50%, with rock sizes between 0.5 and 1 m in diameter (Table 3).

Diagnostic taxa: trees include *Acacia robusta*, *Catha edulis*, *Euphorbia ingens*, *Ficus craterostoma*, *Schrebera alata* and *Sclerocarya birrea*; herbaceous taxa include the forbs *Commelina erecta*, *Helichrysum intricatum*, *Hypoestes aristata* and *Sanseviera hyacinthoides*; the grasses are *Aristida canescens* and *Eragrostis heteromera*.

Dominant/prominent taxa: conspicuous dominant taxa are trees such as *Acacia ataxacantha*, *Hippobromus pauciflorus* and *Ziziphus mucronata*, and grasses such as *Panicum deustum*, *Setaria sphacelata* and *Themeda triandra*.

Notes on floristic diversity: the subassociation has a grassland-savanna species combination in species group H which it shares with Subassociation 4.2 (Table 1). The mean number of species encountered per sample plot is 46, together with Subassociation 4.2, the highest number recorded per relevé for any of the vegetation units of rock habitats. A total number of 105 plant taxa were recorded (eight relevés) (Table 3). Five SCPE endemics, of which two are Red Data List taxa namely *Elephantorrhiza praetermissa* and *Zantedeschia pentlandii*, and five near-endemics are found in this subassociation (Table 2).

4.2. *Setario lindenbergianae–Combretetum mollis diospyretosum nitensis* subass. nova hoc loco

Nomenclatural type: relevé 81 (holotypus).

Species group G (Table 1).

Environmental data: see description of Subassociation 4.1. This subassociation represents bush clumps of rocky ridges, which is restricted to grassland on moist, cool southern aspects (Table 3).

Diagnostic taxa: predominantly woody ones, namely *Buddleja auriculata*, *B. salviifolia*, *Diospyros lycioides* subsp. *nitens*, *Jasminum quinatum*, *Rhus rigida* and *Triaspis glaucophylla*; the only diagnostic forb is *Pupalia lappacea*.

Dominant/prominent taxa: conspicuous woody species are *Apodytes dimidiata*, *Combretum molle*, *Hippobromus pauciflorus* and *Rhoicissus tridentata*; grasses include *Heteropogon contortus*, *Panicum deustum*, *Setaria sphacelata* and *Themeda triandra*.

Notes on floristic diversity: Species group H (Table 1) shows a strong floristic connection with Subassociation 4.1 due to the similar geographical distribution, just on different aspects of the same hills. The mean number of species encountered per sample plot is 46, the highest mean number recorded per relevé in the data set. The total number of plant species for this subassociation is 110 (seven relevés), the richest diversity of species recorded for any rock habitat in the SCPE (Table 3). Of the 10 taxa of conservation value in this subassociation, four are SCPE endemics and five are SCPE near-endemics. Of these, three are Red Data List taxa (Table 2). Three taxa are restricted to the subassociation, namely *Berkheya insignis* (endemic form), *Eucomis montana* (Rare in the Red Data List) and *Gnidia caffra* (endemic form).

4.3. *Setario lindenbergianae–Combretetum mollis aloetum aculeatae* subass. nova hoc loco

Nomenclatural type: relevé 20 (holotypus).

Species group I (Table 1).

Environmental data: a subassociation dominated by a dense herbaceous cover on level ridges situated on midslopes and scarps of grass-covered norite hills. It occurs on red clay soils of the Mispah Form, with the soil surface covered by 70–80% rock of a relatively large size of 4 to 7 m in diameter (Table 3).

Diagnostic taxa: the fern *Cheilanthes hirta*; the succulents *Aloe aculeata*, *Kalanchoe rotundifolia*, *Plectranthus xerophilus* and *Sansevieria aethiopica*; the forbs, *Gloriosa superba* and *Tripteris auriculata*, dominate the community; two undescribed *Cyphostemma* species; *Sporobolus ioclados* and *Trachypogon spicatus* are the grasses.

Dominant/prominent taxa: woody species are the trees *Barleria rotundifolia*, *Catha transvaalensis*, *Croton gratissimus*, *Kirkia wilmsii* and the small shrub *Chrysanthemoides monilifera*; conspicuous grasses include *Andropogon schirensis* and *Eragrostis nindensis*.

Notes on floristic diversity: a noteworthy floristic relationship exists with Association 2 in species group C (Table 1), which can be ascribed to occurrence on the scarps of hills. The mean number of species encountered per sample plot is 39 and the total number for the subassociation is 103 (seven relevés) (Table 3). Six SCPE endemics, six near-endemics and five Red Data List taxa are recorded (Table 2). Of these 14 taxa of conservation value, three near-endemics are restricted to it, namely *Aloe reitzii* var. *reitzii* (Indeterminate in Red Data List), *Chlorophytum cyperaceum* and *Plectranthus xerophilus*.

5. *Brachiario serratae–Viticetum wilmsii* ass. nova hoc loco

Nomenclatural type: relevé 71 (holotypus).

Species group L (Table 1).

Environmental data: this association is a dry bush clump of any aspect, situated on exposed iron-rich norite and magnetite ridges, on midslopes and scarps of hills. It occurs on red and black clay soils of the Mispah Form (ortic A-horizon) and Milkwood Form (melanic A-horizon) underlain by hard rock. The soil surface is covered by 50–60% rock, of an average size of 2.5–3 m in diameter (Table 3). Slope of the habitat is usually moderate (3–7°).

Diagnostic taxa: dominant species are forbs such as *Rhynchosia spectabilis*, *Ruellia cordata* and *Pearsonia aristata*; the succulent *Aloe verecunda*; the sedge *Bulbostylis burchellii* and the grasses *Aristida junciformis*, *Brachiaria serrata* and *Tristachya rehmannii*.

Dominant/prominent taxa: woody species are *Apodytes dimidiata*, *Catha transvaalensis*, *Olea capensis* subsp. *enervis* and *Vitex obovata* subsp. *wilmsii*; conspicuous taxa include *Aloe castanea* and *Sphedamnocarpus pruriens*.

Notes on floristic diversity: the community has a marked floristic grassland affinity in species group X with Association 11 (Table 1). The mean number of species encountered per sample plot is 40, with the total number for this association being relatively high at 109 species (seven relevés) (Table 3). Six SCPE endemics and six SCPE near-endemics, of which three are Red Data List taxa, were recorded (Table 2).

6. *Cymbopogono validi–Brachylaenetum rotundatae* ass. nova hoc loco

Nomenclatural type: relevé 51 (holotypus).

Species group M (Table 1).

Environmental data: this association represents bush clumps in grassland on all aspects of hills with norite and ferrogabbro rocky ridges. It usually occurs at higher altitudes than the other associations, and is found on midslopes and scarps on red clay soils of the Mayo and Mispah Forms. It lies on gently sloped areas (1–5°). Rock cover on the surface is 60–80%, with rocks reaching an average size of 3–5 m in diameter (Table 2).

Diagnostic taxa: herbaceous taxa include the forbs *Pachycarpus transvaalensis*, *Pearsonia sessilifolia*, *Rhynchosia hirta*, *Senecio oxyriifolius* and *Solanum supinum*; woody species include the tree *Brachylaena rotundata*, the shrub *Grewia villosa* and the bushy *Felicia filifolia*.

Dominant/prominent taxa: important dominant taxa are trees such as *Catha transvaalensis*, *Olea capensis* subsp. *enervis* and *Ziziphus mucronata*, and grasses such as *Cymbopogon excavatus*, *C. validus*, *Heteropogon contortus* and *Themeda triandra*.

Notes on floristic diversity: no noteworthy floristic links are evident with associations outside the major group (alliance). The mean number of species encountered per sample plot is 34, with a high total number of 109 plant taxa (seven relevés) (Table 3). Five SCPE endemics and five near-endemics, of which three are Red Data List taxa, are found in this association (Table 2).

7. *Aloo pretoriensis–Xerophytetum retinervis* ass. nova hoc loco

Nomenclatural type: relevé 136 (holotypus).

Species group N (Table 1).

Related to the *Zantedeschio pentlandi–Aloetum castaneae* (Siebert *et al.* 2002d).

Environmental data: this association is an open, sparse bush clump of norite and pyroxenite ridges, on midslopes and scarps of hills. It occurs on black and red clay soils of the Glenrosa and Mispah Forms on cool south and southeast aspects. The soil surface is covered by 60–80% rock of an average size of 2.5–3.5 m in diameter (Table 3). Slope of the habitat is usually 1–5°.

Diagnostic taxa: dominated by forbs such as *Convolvulus sagittatus*, *Dalechampia galpinii*, *Gnidia varia-*

bilis, *Jatropha latifolia* and *Justicia protracta*; the diagnostic shrub is *Gymnosporia buxifolia*; the succulent *Aloe pretoriensis*.

Dominant/prominent taxa: woody species include the shrubs *Hippobromus pauciflorus*, *Pavetta* sp. nov. and *Vitex obovata* subsp. *wilmsii*; important conspicuous grasses include *Aristida transvaalensis*, *Cymbopogon excavatus* and *Themeda triandra*.

Notes on floristic diversity: the association has several floristic relationships with the rest of the data set. The mean number of species encountered per sample plot is 33, with 89 species the total number for this association (six relevés) (Table 3). Of the 12 taxa of conservation value, no taxa are restricted to it. Six SCPE endemics and five SCPE near-endemics were recorded, of which four are Red Data List taxa (Table 2).

8. *Tephrosio purpureae–Rhoicissetum tridentatae* ass. nova hoc loco

Nomenclatural type: relevé 320 (holotypus).

Species group O (Table 1).

Environmental data: this vegetation type is a typical ecotone between *Brachiario serratae–Melhanietum randii* Rocky Grassland and *Themedo triandrae–Combretion mollis* of Rocky Ridges in the southern region of the SCPE. It is open shrubland in moist grassland on midslopes and scarps of undulating norite or pyroxenite hills. The habitat has a level slope of 1–3°, restricted to south and west aspects. Soils are typical red and black clays of the Mayo and Milkwood Forms. Rock size is 1–3.5 m in diameter and cover 50–70% of the soil surface (Table 3).

Diagnostic taxa: the grassland forb species *Dioscorea sylvatica*, *Helichrysum albilanatum*, *Rhynchosia minima*, *Tephrosia purpurea* and *Zornia linearis*; the grasses *Digitaria argyrograpta*, *Eragrostis curvula* and *Hyparrhenia filipendula*; the trees *Canthium mundianum*, *Rhus sekhukhuniensis* and *Rhus discolor* (suffrutex).

Dominant/prominent taxa: the trees/shrubs *Euclea crispa*, *Hippobromus pauciflorus*, *Olea capensis* subsp. *enervis*, *Rhoicissus tridentata* and *R.* sp. nov.; the grass *Cymbopogon excavatus*.

Notes on floristic diversity: this association's floristic relationships are typical for the alliance (Table 1). The mean number of species encountered per sample plot is 34 and the total number of plant species for this association is 75 (three relevés) (Table 3). A high number of taxa of conservation value are found in this association (13), and of these seven are SCPE endemics and six are SCPE near-endemics. Four of these are Red Data List taxa (Table 2). Two taxa with conservation status are restricted to the association, namely the near-endemic *Helichrysum albilanatum* and the Rare (R) endemic *Rhus sekhukhuniensis*.

9. *Sporobolo fimbriati–Rhamnetum prinoidis* ass. nova hoc loco

Nomenclatural type: relevé 4 (holotypus).

Species group Q (Table 1).

Environmental data: this is a distinct association of moist riverbank thicket on raised banks of mountain streams in the valleys between undulating grass-covered norite and pyroxenite hills. It lies on a gentle slope of 1–3°. Soils are characteristically a moist 'humus-rich' sandy loam on a rocky substrate. Approximately 60–70% of the soil surface is covered by rocks, with a size of 3.5–5.5 m in diameter (Table 3).

Diagnostic taxa: tree species are prominent, namely *Cassinopsis ilicifolia*, *Leucosidea sericea* and *Rhamnus prinoides*; forbs are *Freesia laxa*, *Kalanchoe paniculata* and *Thunbergia atriplicifolia*; a sedge *Scleria dieterlenii* and the grass *Sporobolus fimbriatus*.

Dominant/prominent taxa: other important trees are *Chionanthus foveolatus* and *Olinia emarginata*; the grasses are *Aristida transvaalensis*, *Cymbopogon validus*, *Eragrostis racemosa* and *Panicum deustum*.

Notes on floristic diversity: the association follows the floristic affinities of the alliance, but is characterized by the absence of the taxa in species group P and Y due to the presence of moist, lowland soils (Table 1). The mean number of species encountered per sample plot in this association is 34, with the total number of 64 plant species (five relevés) (Table 3). Four taxa of interest occur in this association, namely two SCPE endemics and two near-endemics (Table 2).

10. *Eragrostio lehmannianae–Hippobrometum pauciflori* Association (Siebert *et al.* 2002b)

10.1. *Eragrostio lehmannianae–Hippobrometum pauciflori rhoetosum batophyllae* Subassociation (Siebert *et al.* 2002b)

10.2. *Eragrostio lehmannianae–Hippobrometum pauciflori sorgetosum bicoloris* Subassociation (Siebert *et al.* 2002b)

10.3. *Eragrostio lehmannianae–Hippobrometum pauciflori eucleetosum crispae* Subassociation (Siebert *et al.* 2002b)

10.4. *Eragrostio lehmannianae–Hippobrometum pauciflori enteropogono macrostachyos* subass. nova hoc loco

Nomenclatural type: relevé 334 (holotypus).

Species group S (Table 1).

Environmental data: this vegetation type represents transformed savanna on cool, south and east aspects of norite hills. It covers moderate midslopes and scarps (3–9°). The community is restricted to sandy loam soils in the northern parts of the SCPE. Approximately 20–40% of the soil surface is covered by rocks, with a diameter of >500 mm (Table 2).

Diagnostic taxa: the shrubby *Psiadia punctulata*; the grasses *Cynodon dactylon*, *Enteropogon macrostachys*, *Eragrostis lehmanniana* and *Panicum coloratum*.

Dominant/prominent taxa: prominent trees are *Acacia caffra*, *Euclea crispa*, *Hippobromus pauciflorus* and *Rhoicissus tridentata*.

Notes on floristic diversity: no clear-cut floristic links exist with other plant communities of rocky ridges and it is characterized by the absence of the taxa of rocky habitats listed in species group Y (Table 1). Intense harvesting of wood and overgrazing of the veld is indicated by the low frequency of taxa in species groups T, Z and AG

(Table 1). The mean number of species encountered per sample plot is 20 and the total number is 35 (three relevés) (Table 3). These numbers are the lowest recorded for the rock habitats of the SCPE. None of the five plant taxa with conservation value are restricted to it and comprise three SCPE endemics and two near-endemics, of which one is a locally common Red Data List taxon (Table 2).

III. *Ursinio nanae–Myrothamnion flabellifoli* all. nova hoc loco

Nomenclatural type: *Ursinio nanae–Myrothamnetum flabellifoli* (holotypus), Association 11 described in this paper. This proposed alliance is floristically related to the *Myrothamnus flabellifolius–Ursinia nana* Community of Smit *et al.* (1997).

Species group W (Table 1).

Environmental data: alliance of rocky flats on footslopes, midslopes and scarps of predominantly ultramafic hills and to a lesser extent also hills of the Transvaal Sequence. The habitat occurs on all aspects and is gently to moderately sloped (1–9°). Approximately 60–90% of the soil surface is covered by flat rocks exposed at ground level with a relatively large diameter of >10 m (Table 3). Soils are sandy and ‘humus-rich’ in hollows and fissures in the bedrock.

Diagnostic taxa: see description of Association 11.

Dominant/prominent taxa: see description of Association 11.

Notes on floristic diversity: a strong floristic affinity exists with the alliance of rocky ridges, which is confirmed by species groups Y and Z (Table 1). The mean number of species encountered per sample plot is ± 29, and the total number of plant species is 83 taxa (14 relevés) (Table 3). This alliance has 12 plant taxa of conservation value, of which three are SCPE endemics and seven near-endemics. Six Red Data List taxa occur. Together with Association 4, this is the highest number of Red Data List taxa recorded for rock habitats in the SCPE. None of these taxa are restricted to the proposed alliance.

11. *Ursinio nanae–Myrothamnetum flabellifoli* ass. nova hoc loco

Nomenclatural type: relevé 35 (holotypus).

Species group W (Table 1).

Related to the *Myrothamnus flabellifolius–Ursinia nana* Community (Smit *et al.* 1997).

Environmental data: the vegetation structure is shrubby and grassy and widespread throughout hillsides of the study area and variations of this association are probably widespread along the north-eastern escarpment. It occurs on all aspects of footslopes, midslopes and scarps. It lies on gentle to moderate slopes (1–9°) and is found predominantly on moist, ‘humus-rich’ sandy soils. Approximately 60–90% of the soil surface is covered by rocks, with a mean size of >10 m in diameter (Table 3).

Diagnostic taxa: dominated by forbs including *Crassula swaziensis*, *Craterostigma wilmsii*, *Oldenlandia herbacea* and *Pearsonia cajanifolia*; grasses are *Aristida adscensionis*, *Eragrostis capensis*, *E. pseudosclerantha* and *Melinis repens*.

Dominant/prominent taxa: the fern *Pellaea calomelanos*; the shrubby *Xerophyta retinervis*; the succulents *Aloe castanea* and *Crassula sarcocaulis*; the grasses *Aristida transvaalensis* and *Eragrostis racemosa*.

Notes on floristic diversity: the same as the alliance. Association is common throughout the Bankenveld.

11.1. *Ursinio nanae–Myrothamnetum flabellifoli euphorbietosum cooperi* subass. nova hoc loco

Nomenclatural type: relevé 35 (holotypus).

Species group U (Table 1).

Environmental data: widespread throughout the Roossenekal Subcentre on north, south and west aspects of footslopes, midslopes and scarps of undulating norite hills. It lies on gentle slopes (1–3°) and is found predominantly on sandy soils. Approximately 70–80% of the soil surface is covered by rocks, with a mean diameter of >10 m (Table 3).

Diagnostic taxa: herbaceous species are the fern *Cheilanthes involuta*, the geophyte *Stylochaeton natalensis*, and the forbs *Dioscorea dregeana* and *Orthosiphon amabilis*; trees/shrubs include *Vangueria infausta* and a short-stemmed form of the succulent *Euphorbia cooperi*; grasses are *Aristida scabrivalvis* and *Microchloa caffra*.

Dominant/prominent taxa: the succulent *Crassula swaziensis* and woody *Myrothamnus flabellifolius* are dominant forbs; prominent shrubs are *Euclea crispa*, *Mundulea sericea* and *Rhoicissus tridentata*; frequently occurring grasses are *Aristida transvaalensis*, *Eragrostis pseudosclerantha*, *E. racemosa* and *Heteropogon contortus*.

Notes on floristic diversity: a strong floristic relationship exists with Subassociation 11.2 in species group W and Association 5 species group X (Table 1). The mean number of species encountered per sample plot is 30 and the total number of plant species is 66 taxa (six relevés) (Table 3). None of the ten plant taxa of conservation value, namely two SCPE endemics, six near-endemics and five Red Data List taxa, are restricted to the subassociation (Table 2).

11.2. *Ursinio nanae–Myrothamnetum flabellifoli xerophytosum villosae* subass. nova hoc loco

Nomenclatural type: relevé 97 (holotypus).

Species group V (Table 1).

Environmental data: this community is widespread throughout the SCPE. It occurs on rocky flats with ‘humus-rich’, sandy soils. It covers moderately sloped footslopes, midslopes and scarps of 3–9° on all aspects of undulating norite and pyroxenite hills. Approximately 60–90% of the soil surface is covered by large rocks, with a mean size of >10 m in diameter (Table 3).

Diagnostic taxa: herbs are most diagnostic and include the fern *Cheilanthes eckloniana* and fern ally *Selaginella dregei*, the forbs *Kedrostis foetidissima*, *Thesium burkei* and *Xerophyta villosa*; the succulents *Crassula alba*, *Euphorbia schinzii*, *Kalanchoe luciae* and *Kleinia longiflora*; *Rhus wilmsii* is a woody suffrutex.

Dominant/prominent taxa: taxa of importance are the grasses *Aristida transvaalensis* and *Melinis nerviglumis*; the succulents *Aloe castanea* and *Crassula sarcocaulis* are conspicuous members.

Notes on floristic diversity: floristic relationships are similar to that of Subassociation 11.1 (Table 1). The mean number of species encountered per sample plot is 27 and the total number of plant species is 75 taxa (eight relevés) (Table 3). There are nine taxa of conservation value in the subassociation, namely three SCPE endemics, five near-endemics and four Red Data List taxa (Table 2).

IV. *Combreto erythrophylli–Celtion africanae* (Siebert *et al.* 2002c)

Species group AF (Table 1).

Environmental data: this well-documented alliance (Coetzee 1975; Van der Meulen 1979; Matthews *et al.* 1992) represents forests and dense woodlands in rocky refugia of the SCPE. It is a rare vegetation type and can be found on southern aspects of valleys, and mountain footslopes, midslopes and crests. The habitat is characterized by large norite boulders of minimum 2 m high and the mean rock diameter ± 0.5–2.5 m and covers ± 10–70% of the soil surface. It is characterized by gentle to moderate slopes (1–7°). Soil types are a red or black clay base on unconsolidated material and include the Mayo (lithocutanic B-horizon) and the Oakleaf (neocutanic B-horizon) Forms.

Diagnostic taxa: the trees *Calodendrum capense* and *Celtis africana*, the shrub *Diospyros whyteana* and the succulent *Aloe arborescens*.

Dominant/prominent taxa: prominent taxa include the woody species *Acacia ataxacantha*, *Allophyllus africanus*, *Ehretia rigida*, *Halleria lucida*, *Hippobromus pauciflorus* and *Ziziphus mucronata*; *Panicum deustum* is the dominant grass.

Notes on floristic diversity: a strong floristic affinity exists with Association 4 in species group AF (Table 1), which indicates its relationship with the tall bush clumps of rocky ridges. The mean number of species encountered per sample plot is ± 36 and the total number of plant species is 79 taxa (11 relevés) (Table 3). There are five taxa of conservation value associated with this major group, namely two SCPE endemics and three SCPE near-endemics (Table 2). Of these taxa, an undescribed *Gymnosporia*, is restricted to the alliance.

12. *Acacio ataxacanthae–Celtidetum africanae* (Matthews *et al.* 1992)

12.1. *Acacio ataxacanthae–Celtidetum africanae clausenetosum anisatae* subass. nova hoc loco

Nomenclatural type: relevé 67 (holotypus).

Species group AA (Table 1).

Environmental data: in the Roossenekal Subcentre this subassociation represents wooded rocky refugia, mostly associated with boulders around caves, in kloofs and below cliffs, or stone walls of old kraals. It is a vegetation unit on red clay soils of the Mayo and Oakleaf Forms. These units occur on footslopes and midslopes of undulating norite hills. The gentle slopes vary from 3–7° and east-south-west aspects are predominant. Rock cover percentage varies from 10 to 40% and rock diameter is 1–1.5 m (Table 3).

Diagnostic taxa: trees are most dominant and include *Clausena anisata*, *Clerodendrum glabrum*, *C. myricoides*, *Ficus thonningi*, *Obetia tenax* and the succulent *Aloe marlothii*; forbs are *Abutilon austro-africanum*, *Cyathula cylindrica*, *Hermannia floribunda* and *Scadoxus puniceus*; grasses include *Brachiaria brizantha*, *Digitaria sanguinalis*, *Setaria verticillata* and *Urochloa mossambicensis*.

Dominant/prominent taxa: important dominant taxa include the woody species *Acacia ataxacantha*, *Allophyllus transvaalensis*, *Celtis africana* and *Diospyros whyteana*, the forb *Pavonia burchellii*, and the grasses *Panicum deustum* and *P. maximum*.

Notes on floristic diversity: strong floristic links exist with Subassociation 12.2 in species group AC and a specific Afromontane link with Association 13 in species group AE (Table 1). Species shared with other rock habitats are few. The mean number of species encountered per sample plot is a high 41 (Table 3). The total number of plant species for this subassociation is 68 (six relevés). Two taxa of conservation value occurs in this subassociation, namely an undescribed endemic *Cyphostemma* species (*Siebert 1383*) and the near-endemic *Euphorbia lydenburgensis*.

12.2. *Acacio ataxacanthae–Celtidetum africanae acacietosum galpinii* subass. nova hoc loco

Nomenclatural type: relevé 182 (holotypus).

Species group AB (Table 1).

Environmental data: this vegetation type is slightly transformed woodlands of rocky banks along the larger rivers in the valleys. The habitat lies between norite outcrops on black and red clay soils derived from alluvium. It lies on gentle slopes of 3–5°. Soils are predominantly the Mayo and Oakleaf Forms. Approximately 20–70% of the soil surface is covered by rocks, with an average diameter of 0.5–2.5 m (Table 3).

Diagnostic taxa: the woody species *Acacia galpinii*, *Combretum erythrophyllum*, *Ficus sur*, *Flueggea virosa*, *Melia azedarach* (naturalized alien) and *Spirostachys africana*; forbs are *Achyranthes aspera*, *Barleria obtusa*, and the climbers *Cardiospermum corindum* and *Secamone acutifolia*.

Dominant/prominent taxa: *Celtis africana* and *Schotia brachypetala* are prominent trees; important dominant grasses include *Panicum deustum* and *P. maximum*.

Notes on floristic diversity: the subassociation shows the same floristic links as Subassociation 12.1 (Table 1). The mean number of species encountered per sample plot is 33 and the total number is 64 (three relevés) (Table 3). It has two taxa of conservation value, namely a locally common near-endemic and an undescribed endemic *Gymnosporia* (*Siebert 458*) (Table 2).

13. *Andrachno ovalis–Allophylletum transvaalensis* ass. nova hoc loco

Nomenclatural type: relevé 406 (holotypus).

Species group AD (Table 1).

Environmental data: this association comprises two relict Afromontane Forest patches on the summit of the Leolo Mountains (1 800 m a.s.l.). It is associated with norite substrates and boulders of 2–6 m high. The habitat has a southern aspect and a gentle slope of 1–3°. Approximately 20–40% of the soil surface is covered by rocks with a mean diameter of 500–750 mm (Table 3), which can be up to 3 m high. Soil is black clay of the Oakleaf Form.

Diagnostic taxa: dominated by woody species, namely *Andrachne ovalis*, *Gymnosporia* sp. nov. (*Van Wyk & Siebert 13351*), *Ilex mitis*, *Kiggelaria africana*, *Prunus africana* and *Senna occidentalis*; forbs include *Polygala virgata*, *Senecio tamoides*, *Solanum aculeastrum* and *Urtica lobulata*.

Dominant/prominent taxa: conspicuous taxa are the tree *Halleria lucida*, the climber *Clematis brachiata* and the grass *Panicum deustum*.

Notes on floristic diversity: strong floristic affinities exist with Association 12 in species groups AE and AF (Table 1). It also shares woodland species with Association 4 in species group AF (Table 1). However, this is not a true vegetation type of rock habitats, but due to the subsequent undersampling and existence of only two forest patches (2 relevés). The community is described here for lack of better placement. The mean number of species encountered per sample plot is 35 and the total number of plant species is 65 taxa (two relevés) (Table 3). This association has one taxon with conservation status, namely the undescribed, near-endemic *Gymnosporia* sp. nov. (*Van Wyk & Siebert 13351*) (Table 2). Another noteworthy taxon is *Nemesia zimbabwensis* with its disjunct distribution shared with the Eastern Highlands of Zimbabwe. Both these taxa are restricted to the association. Its relict status gives the community special conservation significance as a rare plant community (perhaps the rarest in the SCPE).

DISCUSSION

Ordination and environmental factors

The naturally sparsely vegetated appearance of rocky habitats can be ascribed to the relatively high surface cover of rock, comprising many taxa typical for this habitat in the northern provinces of South Africa. When compared with other habitats of the SCPE (Siebert 2001), its environmental factors are relatively homogeneous. A combination of factors such as terrain type (slope), soil texture (clay/sand content) and rockiness (rock size and rock cover), affect the species composition of these plant communities. The ordination supported a gradient which is mainly the consequence of rockiness.

The scatter diagram displays the distribution of relevés along the first and second ordination axes (Figure 2). The vegetation units are represented as groups, their distribution on the scatter diagram corresponding with certain physical environmental conditions. The rockiness, slope and soil texture determine a definite gradient that is depicted by both the first (eigen value = 0.669) and second axis (eigen value = 0.456). Rockiness, slope and soil texture determine the moisture retention and drainage of the habitat. The gradient on the x-axis expresses rock cover as a percentage of the soil surface, with the left extreme of the scatter diagram representing rocky flats with its continuous layers of rock at the soil surface and the right depicting the large boulders with large areas of open soil between them, which are typical for rocky refugia. On the y-axis, the gradient indicates higher moisture availability over the long term at the top of the diagram, because clayey soils on moderate slopes with large areas covered with rock remain moist over a longer period. Steep slopes with sandy soils and low rock cover dry out quickly and are at the bottom of the diagram. The x-axis also exhibits a gradient with deep soils at the right and shallow soils at the left.

All these gradients correlate closely with each other and have a strong influence on the vegetation structure and species composition. The three most dominant and conspicuous taxa of each growth form (trees/shrubs/suffrutices, forbs/sedges and grasses) are given for each of the four major vegetation types (alliances) depicted in the scatter diagram (Table 4).

A vegetation key is presented to aid with the identification of the various plant communities (Table 5). The definitions are broad indications of typical groups and should be seen as a guideline. A diagnostic characteristic of the vegetation or habitat is given, followed by a most diagnostic and a most visual species of the plant community. The first species is restricted to the specific com-

TABLE 4.—Nine most dominant and conspicuous plant taxa of each of major vegetation types depicted in DECORANA scatter diagram

Major vegetation type (Alliance)	Growth form		
	Trees/shrubs	Forbs/sedges	Grasses
I. *Setario lindenbergianae–Crotion gratissimi*	*Croton gratissimus* *Ficus abutilifolia* *Vepris reflexa*	*Asparagus intricatus* *Rhoicissus sekhukhuniensis* *Sarcostemma viminale*	*Andropogon schirensis* *Panicum deustum* *Setaria lindenbergiana*
II. *Themedo triandrae–Combretion mollis*	*Combretum molle* *Hippobromus pauciflorus* *Pavetta zeyheri*	*Cyphostemma woodii* *Gerbera jamesonii* *Rhoicissus tridentate*	*Cymbopogon excavatus* *Setaria sphacelata* *Themeda triandra*
III. *Ursinio nanae–Myrothamnion flabellifoli*	*Aloe castanea* *Mundulea sericea* *Xerophyta retinervis*	*Crassula sarcocaulis* *Myrothamnus flabellifolia* *Ursinia nana*	*Aristida transvaalensis* *Eragrostis pseudosclerantha* *Melinis nerviglumis*
IV. *Combreto erythrophylli–Celtion africanae*	*Celtis africana* *Combretum erythrophyllum* *Diospyros whyteana*	*Clematis brachiata* *Lippia javanica* *Pavonia burchelii*	*Panicum deustum* *Panicum maximum* *Urochloa mosambicensis*

TABLE 5.—Key to syntaxa of rock habitats of Sekhukhuneland Centre of Plant Endemism

Leads/description	Go to/syntaxon
1a Tall, moist woodland (*Celtis africana* & *Panicum deustum*)	**2**
b Short woodland, herbland and grassland (*Aloe castanea* & *Euclea crispa*)	**3**
2a Mountain plateau (*Andrachne ovalis* & *Allophylus transvaalensis*)	14. *Andrachno ovalis–Allophylletum transvaalensis*
b Mountain slope and valley (*Pavonia burchellii* & *Ziziphus mucronata*)	**4**
3a Mean rock size > 9 m (*Oldenlandia herbacea* & *Xerophyta retinervis*)	**5**
b Mean rock size < 9 m (*Combretum molle* & *Hippobromus pauciflorus*)	**6**
4a Valley (riverbanks) (*Combretum erythrophyllum* & *Acacia galpinii*)	12.2 *Acacio ataxacanthae–Celtidetum africanae acacietosum galpinii*
b Mountain slope (*Clausena anisata* & *Allophylus africanus*)	12.1 *Acacio ataxacanthae–Celtidetum africanae clausenetosum anisatae*
5a Slope 3–9° (*Xerophyta villosa* & *Melinis nerviglumis*)	11.2 *Ursinio nanae–Myrothamnetum flabellifoli xerophytosum villosae*
b Slope 1–3° (*Euphorbia cooperi* & *Mundulea sericea*)	11.1 *Ursinio nanae–Myrothamnetum flabellifoli euphorbietosum cooperi*
6a Open woodland or grassland (*Olinia emarginata* & *Cymbopogon excavatus*)	**7**
b Closed woodland (*Ficus abutifolia* & *Maytenus undata*)	**8**
7a Developed soils (*Combretum molle* & *Themeda triandra*)	**9**
b Sand (*Heteropogon contortus*)	**10**
8a Mispah soil (*Commiphora marlothii* & *Croton gratisimus*)	2. *Setario lindenbergianae–Crotonetum gratissimi*
b Bonheim soil (*Mimusops zeyheri* & *Vepris reflexa*)	1. *Vepro reflexae–Mimusopetum zeyheri*
9a Glenrosa soil (*Xerophyta retinervis*)	**11**
b Other soils (*Apodytes dimidiata* & *Zantedeschia pentlandii*)	**12**
10a Rock cover 20–40% (*Enteropogon macrostachys* & *Hippobromus pauciflorus*)	10.4 *Eragrostio lehmannianae–Hippobrometum pauciflori enteropogono macrostachyos*
b Rock cover 60–70% (*Rhamnus prinoides* & *Cymbopogon validus*)	9. *Sporobolo fimbriati–Rhamnetum prinoidis*
11a South-east aspects (*Aloe pretoriensis* & *Cussonia transvaalensis*)	7. *Aloo pretoriensis–Xerophytetum retinervis*
b North-east aspects (*Grewia monticola* & *Elephantorrhiza praetermissa*)	3. *Grewio monticolae–Elephantorrhizetum praetermissae*
12a Variety of rock substrates (*Catha transvaalensis*)	**13**
b Restricted to norite (*Dombeya rotundifolia* & *Diospyros lycioides*)	**14**
13a All aspects (*Scolopia zeyheri*)	**15**
b Southern aspects (*Tephrosia pupurea* & *Rhoicissus tridentata*)	8. *Tephrosio purpureae–Rhoicissetum tridentatae*
14a Slope 3–15° (*Peltophorum africanum* & *Dovyalis zeyheri*)	**16**
b Slope 1–3° (*Combretum molle* & *Aloe aculeata*)	4.3 *Setario lindenbergianae–Combretetum mollis aloetum aculeatae*
15a Also on ferrogabbro (*Brachylaena rotundata* & *Cymbopogon validus*)	6. *Cymbopogono validi–Brachylaenetum rotundatae*
b Also on magnetite (*Brachiaria serrata* & *Vitex obovata* subsp. *wilmsii*)	5. *Brachiario serratae–Viticetum wilmsii*
16a Southern aspect (*Diospyros lycioides* subsp. *nitens* & *Heteropogon contortus*)	4.2 *Setario lindenbergianae–Combretetum mollis diospyretosum nitensis*
b Northern aspect (*Catha edulis* & *Melinis nerviglumis*)	4.1 *Setario lindenbergianae–Combretetum mollis cathetosum edulis*

munity only, and the second is dominant, but also occurs in other communities. Where one species is given, no species was restricted to the group only.

Diversity and conservation

Much of the vegetation distribution of the SCPE is attributed to the vegetation dynamics and historic evolution of the floristics of the region, which is influenced by three factors, climate, topography and soils (Siebert 1998). It has been shown that the vegetation of rocky outcrops is specifically adapted to the chemical environment (Morrey *et al.* 1989; Bredenkamp & Deutschlander 1995; Tyler 1996). When considering the large number of associations described in this paper, it is speculated that the soil chemistry of the rock habitats in the SCPE is partly responsible for the unique communities and plant diversity that occur there (Siebert 2001).

Rock habitats are characterized by high spatial heterogeneity due to the range of differing aspects and slopes (topography), all of which result in differing soil, light and hydrological conditions. Variation in aspect and soil drainage has proven to be an important predictor of plant diversity in the SCPE (Siebert 2001). This is attributed to landscapes with spatially heterogeneous abiotic conditions, which provide a diversity of potential niches for plants. Plant species richness and diversity is significantly higher in sites with high geomorphological heterogeneity (Burnett *et al.* 1998). However, rock habitats are usually isolated, which means that should they be disturbed, the species richness will be influenced negatively due to the long distances between similar plant communities (Bruun 2000).

Vegetation units or rock habitats in the SCPE require special protection against disturbances and should be considered for conservation purposes in the light of the rapidly developing mining industry of the region. Already, some plant communities of rock habitats in the SCPE (especially the rocky refugia) are not as diverse as they were in the past, due to extensive harvesting of firewood and building material (Crookes *et al.* 2000). These Afromontane forests of rocky refugia are of continental conservation importance (White 1981). In addition, certain SCPE plant endemics of rock habitats are restricted to specific communities, and once removed, will probably not return. If it is considered that 'disclimax' in dry woodlands (<1 000 mm/annum) created through past land use activities, will not develop into stands similar to the previous state (Roth 1999), and given the present state of fragmentation and continued disturbance taking place within SCPE ecosystems, the rock habitats of the SCPE require immediate attention. All the plant communities of rock habitats presented in this paper are of conservation value, as they provide important islands to sustain biodiversity.

CONCLUSIONS

The classification obtained by TWINSPAN and refined by Braun-Blanquet procedures resulted in 17 vegetation units (plant communities) that can be related to environmental factors. These vegetation units should be considered as ecologically interpretable plant communities for the area concerned. The classification of these vegetation units as associations is supported by the results of the ordination that pointed towards meaningful relationships between the vegetation and habitat gradients.

It is hoped that the classification and description of the different vegetation units will make a significant contribution towards the understanding of the plant communities of rock habitats of the SCPE and in southern Africa as a whole. The information supplied in this paper can be meaningfully applied in the management and conservation of the respective areas. Proper and sound future assessment of the region's vegetation should include aspects such as species richness, rarity and habitat preference. Such studies will further contribute and benefit decisions on land use management and conservation, and might hold solutions for the rehabilitation of areas disturbed by mining activities in this region.

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Van Wyk, F. Principal Auxiliary Services Officer II. Lable Maker
Viljoen, Ms C.C. N.Dip.(Hort.). Chief Agricultural Development Technician. Plant production

VISITORS CENTRE—CAPE TOWN (GKBC/VC)

Struys, Ms S. Dip.(Market. Manag.), B.A.(Directing). Principal Communications Officer. Centre Manager

August, T. Senior Auxiliary Services Officer. Information services
Fredericks, Ms N.C.E. Senior Auxiliary Services Officer. Visitors' Centre. Information services
Jacobs, A.P. Chief Auxiliary Services Officer. Visitors' Centre. Information services
Jacobs, Ms B.C. Dip.(Travel & Tourism), Dip.(Computer Business). Senior Admin. Clerk II. Facilities Co-ordinator
Malan, Ms C.E. B.Sc.(Hons). Principal Communication Officer: Tour co-ordinator
Williams, G.C. Senior Auxiliary Services Officer. Information

LOWVELD NBG—NELSPRUIT (GLOW)

Britz, R.M. N.Dip.(Forestry). Control Agricultural Technican. Curator

Froneman, W.C.F. N.T.C.III(Hort.), N.Dip.(Nature Cons. & Man.), N.Dip.(Parks & Rec. Admin.), N.T.C.III (Hort.). Control Agricultural Technician. Nursery management & garden development
Haynie, R.D. Senior Handyman
Hurter, P.J.H. B.Sc.(Hons). Control Agricultural Technician. Cycad conservation
Le Roux, Ms L.N. N.H.Dip.(Nature Cons.). Principal Auxiliary Services Officer II. Interpretation
Maqungo, Ms V.L.B. Auxiliary Services Officer. Kiosk
Mathebula, Ms N.R. Accounting Clerk II. Admin. support
Musweli, K.J. Senior Foreman. New development
Ndlovu, L.D. Senior Handyman. Maintenance
Ngwenya, P.S. Auxiliary Services Officer II. Kiosk
Sibanyoni, Ms S.M. Cleaner I
Van der Walt, Mrs G.A.M. Senior Provisioning Admin. Clerk III
Xozumti, M.M. Principal Foreman. Supervisor

NATAL NBG—PIETERMARITZBURG (GNAT)

Tarr, B.B. N.Dip.(Parks & Rec. Admin.), Advanced Dip.(Adult Educ.).
Control Agricultural Technician. Curator

Dlungwane, T.R. Senior Foreman. Garden maintenance
Johnson, Ms I. M.Sc., H.E.D. Senior Agricultural Development Technician
Nonjinge, S.H.B. N.T.C.III(Hort.). Chief Agricultural Development Technician
Sibiya, Ms C.P.T. Cleaner I
Van der Merwe, Mrs M.E.H. Senior Provisioning Admin. Clerk III
Xaba, P.A. (student)
Zimu, M.J. Principal Foreman. Garden

FREE STATE NBG—BLOEMFONTEIN (GFSG)

Gavhi, M.P. N.Dip.(Hort.). Curator

Eysele, Mrs J.P. Senior Provisioning Admin. Clerk III. Admin. support
Harris, Ms S. N.Dip.(Hort.). Senior Agricultural Development Technician
Mbolekwa, L.M. Foreman. Garden
Nakanyane, R.B. Principal Foreman. Garden
Raditlhare, Mrs E.M. Cleaner II
Sebolai, R.P.A.N. Senior Handyman. General maintenance
Thaele, Mrs M.E. Cleaner II

PRETORIA NBG (GPTA)

Behr, Ms C.M. B.Sc.(Hons). Control Agricultural Technician. Curator

Baloyi, K.J. Senior Auxiliary Services Officer II. Garden records
Baloyi, M.S. Dip.(IBM), Dip.(PTM), Dip.(Payroll Admin.). Senior Provisioning Admin. Clerk I. Personnel records and H.R. support
Baloyi, S.J. Senior Handyman
Creighton, Ms D.D. Senior Provisioning Admin. Clerk III. Admin. support
Keyter, B.A. Senior Security Officer II
Klapwijk, N.A. N.Dip.(Hort.), N.Dip.(Plant Prod.), N.Dip.(Diesel Fitting). Control Agricultural Technician
Kutama, B.T. Senior Foreman. Garden development
Makgobola, Ms M.R. Auxiliary Services Officer II. Reception & admin. support
Mariri, J.N. Senior Foreman. Maintenance
Mariri, Ms M.A. Cleaner II
Matshika, S.P. Groundsman II. Cook
Matthews, A.V. B.Tech.(Hort.). Chief Agricultural Development Technician
Modisha, M.D. Cleaner II
Mphaka, Ms N.F. Student Horticulturalist
Mutshinyalo, T.T. N.Dip.(Hort.). Senior Agricultural Development Technician
Noku, Y.A. Principal Foreman. Transport
Solomons, Ms C.V. Senior Auxiliary Services Officer. Records clerk
Venter, W.A. N.T.C.II. Senior Artisan. Workshop and general maintenance

WITWATERSRAND NBG—ROODEPOORT (GWIT)

Turner, Ms S.L. B.Sc.(Hons), N.Dip.(Hort.). Control Agricultural Technician. Curator

Aubrey, Mrs A.E. B.Tech.(Hort.). Chief Agricultural Development Technician. Plant records, interpretation, information (part time)
Baloyi, S.J. Handyman
Dlamini, M.D. N.Dip.(Hort.). Agricultural Development Technician
Hankey, A.J. N.Dip.(Hort.). Control Agricultural Technician. Garden, estate, collections, nursery
Head, Mrs S.E. Dip.(Shorthand & Typing). Provisioning Admin. Officer
Mamosebo, M.A. Factotum
Manyikana, T.M. Factotum
Mmola, Mrs B.E. Cleaner II
Ndou, A.P. Senior Auxiliary Services Officer II. Garden information
Ndzondo, Ms N.L. Senior Provisioning Admin. Clerk I
Ndzondo, Mrs P.G. Cleaner II
Nedambale, M.P. Senior Foreman. Garden
Nemalili, M.E. Senior Foreman. Machines and vehicles
Nenungwi, M.S. Senior Foreman. Nursery
Tebeile, Ms Z.M. Senior Provisioning Admin. Clerk I. Receptionist

RESEARCH DIRECTORATE (RDIR)

PRETORIA

Smith, Prof. G.F. Ph.D., F.L.S. Chief Director: Research & Scientific Services
Rutherford, M.C. Ph.D., Dip.(Datamet.). Deputy Director: Ecology and conservation (Cape Town)
Wolfson, Mrs M.M. Ph.D. Deputy Director: Environmental education and research support

Meyer, Mrs N.L. B.Sc.(Hons) Technician (contract worker)
Marais, Mrs A.C. Senior Secretary IV
Steyn, Mrs E.M.A. D.Sc. Specialist Scientist. Embryology, anatomy, taxonomy

EDUCATION AND RESEARCH SUPPORT—PRETORIA (EDIR)

Wolfson, Mrs M.M. Ph.D. Deputy Director. Physiology/Ecophysiology of Poaceae, carbon uptake metabolism, allocation in response to environmental and management stress

Liebenberg, Mrs E.J.L. Head: Research Support Services, Publications
Naicker, K. Head: Admin. and Human Resources
Potgieter, Mrs E. Principal Librarian
Symonds, Ms A.M. Head: Environmental education

ADMINISTRATION —PRETORIA (RPTA)

Naicker, K. Dip.(Bookkeeping), Cert.(Sales & Market. Manag.), H.Cert.(Prac. Accounting). Assistant Director

Khumalo, N.P. Principal Foreman. Supervisor: Cleaning services
Ledwaba, Mrs D.M. Senior Registry Clerk I
Malefo, R.P. Cleaner II
Marule, P.M. Senior Handyman
Nkosi, Mrs M.P. Specialist Cleaner
Phaahla, M.C. Cleaner II
Pretorius, Ms M.A. Senior Provisioning Admin. Clerk II
Randima, Ms G. Cleaner II
Rukazhanga-Leboho, Ms N. Senior Personnel Practitioner
Sithole, A.M. Cleaner II
Tloubatla, J.M. Driver II. Courier services

ENVIRONMENTAL EDUCATION—NORTHERN AND SOUTHERN GARDENS (EENT/HO)

PRETORIA

Symonds, Ms A.M. N.Dip.(Nature Cons.), H.E.D. Assistant Director. Environmental education
Adams, Ms E.M. Senior Provisioning Admin. Officer. Environmental Education Centre Manager

Maphuta, Mrs M.S. Cleaner II

GOLD FIELDS CENTRE—CAPE TOWN (EECT)

Gaffoor, Ms N. H.E.D. Principal Environmental Education Officer. Co-ordinator: Environmental education
September, Ms M. Senior Provisioning Admin. Clerk II. Admin. support

PRETORIA (EENT/GP)

De Bruyn, Ms A.J. B.Sc.(Zoo., Bot. & Mammalogy). Principal Communication Officer. Co-ordinator: Environmental education

Mathaba, T.C. Environmental Education Officer
Novellie, Mrs E. H.E.D. B.Sc.(Hons) (Zool. & Mammology). Senior Environmental Education Officer. Environmental education

WITWATERSRAND (EENT)

Van der Westhuizen, Mrs S. M.Sc.(Bot.). Principal Communications Officer. Co-ordinator: Environmental education

Molefe, Ms K.E. Dip.(Nature Cons.). Senior Environmental Education Officer
Moore, Mrs J.M. N.H.Dip.(Sec.). Senior Provisioning Admin. Clerk II. Admin. support (part time)

RESEARCH SUPPORT SERVICES AND PUBLICATIONS—PRETORIA (RPUB)

Liebenberg, Mrs E.J.L. M.Sc. Control Agricultural Technician. Cytotaxonomy. Manager

Brink, Mrs S.S. Dip.(Typing). Chief Typesetter. Typesetting, layout, word processing
Condy, Ms G.S. M.A. Chief Industrial Technician. Botanical artist
Du Plessis, Mrs E. B.Sc.(Hons), S.E.D. Chief Language Practitioner. Technical editor. Editing, translating, layout
Germishuizen, G. M.Sc. Assistant Director. Editor
Mapheza, T.P. Senior Provisioning Admin. Clerk III. Bookshop Manager
Momberg, Mrs B.A. B.Sc.(Entomology & Zoology). Principal Language Practitioner. Technical editor. Editing, layout (part time)
Maree, Ms D.J. H.E.D. Senior Computer Operator.
Nkosi, P.B. Senior Provisioning Admin. Clerk I. Bookstore
Turck, Mrs S. B.A.(Information Design). Chief Industrial Technician. Graphic design

MARY GUNN LIBRARY—PRETORIA (RLBP)

Potgieter, Mrs E. B.Libr. Principal Librarian

Fourie, Mrs A.L. B.A., H.Dip.Libr.Sci. Principal Librarian (part time)
Shipalana, Ms K.M. N.Dip. Library and Information Studies (contract worker)

PLANT SYSTEMATICS SUBDIRECTORATE

PRETORIA

Smith, Prof. G.F. Ph.D., F.L.S. Systematics of succulents and rosulate, petaloid monocots

Arnold, T.H. Head: Data Management (Pretoria)
Crouch, N.R. Head: Ethnobotany Unit (Durban)
Koekemoer, Ms M. Curator: National Herbarium (Pretoria)
Leistner, O.A. D.Sc. F.L.S. Scientist (contract worker)
Rourke, J.P. Curator: Compton Herbarium (Cape Town)
Siebert, S.J. Regional Project Co-ordinator: SABONET (Pretoria)
Singh, Ms Y. Curator: Natal Herbarium (Durban)

COMPTON HERBARIUM—CAPE TOWN (RHEC)

Rourke, J.P. Ph.D., F.M.L.S., F.R.S.S.Af. Assistant Director. Systematics of southern African Proteaceae, Stilbaceae

Baatjes, Ms A. Data Capturer (SABONET contract worker)
Chesselet, Ms P.C.M. M.Sc. Senior Agricultural Scientist
Conrad, Ms C. M.Sc. Agricultural Scientist. Molecular systematics laboratory
Cupido, C.N. M.Sc. Chief Agricultural Scientist
Cupido, Mrs C.S. Senior Auxiliary Services Officer II. Technical Assistant
Engelbrecht, Ms M. (SABONET contract worker)
Foster, Mrs S.E. Senior Secretary IV
Kurzweil, H. Ph.D. Specialist Scientist. Systematics of southern African terrestrial orchids
Leith, Mrs J. Senior Provisioning Admin. Clerk III
Manning, J.C. Ph.D. Senior Specialist Scientist. Systematics of Iridaceae and Hyacinthaceae; anatomy
Marinus, Ms E.D.A. Chief Auxiliary Services Officer. Herbarium Assistant
Oliver, E.G.H. Ph.D. Specialist Scientist. Taxonomy of the Ericoideae (Ericaceae)
Parker, Ms F. M.Sc. (SABONET contract worker)
Paterson-Jones, Mrs D.A. (née Snijman) Ph.D. Specialist Scientist. Systematics of Hypoxidaceae; cladistics
Reeves, Ms G. Ph.D. Senior Agricultural Scientist. Molecular systematics (contract worker)
Roux, J.P. N.T.C.III(Hort.), F.L.S., Ph.D. Specialist Scientist. Systematics of Pteridophyta
Williams, Mrs V.J. Data Capturer (SABONET contract worker)

NATAL HERBARIUM—DURBAN (RHED)

Singh, Ms Y. M.Sc., H.E.D. Senior Agricultural Scientist. Taxonomy of Araceae, Hypoxidaceae. Curator

Dimon, Ms Z.Y. B.Sc. Data Capturer (SABONET contract worker)
Govender, Mrs N. B.Sc.(Hons) Data Capturer. *Chironia* systematics (SABONET contract worker)
Hlongwane, Mrs N.C. Cleaner II & messenger
Mazibuko, J.V.G. Senior Auxiliary Services Officer. Herbarium Assistant
Mbonambi, B.M. Groundsman II. Garden maintenance
Nathoo, Ms M. B.Sc. Data Capturer (SABONET contract worker)
Ngwenya, A.M. Senior Agricultural Development Technician. Herbarium Officer. Plant identification and information, Zulu Botanical Knowledge Project
Noble, Mrs H-E. Senior Provisioning Admin. Clerk III
Williams, Ms R. B.Sc.(Hons), H.E.D. Principal Agricultural Scientist

ETHNOBOTANY UNIT—DURBAN (RETH)

Crouch, N.R. Ph.D. Assistant Director. Ethnobotany of southern African flora
Grace, Ms O.M. M.Sc. Assistant Bioprospecting Investigator (contract worker)

NATIONAL HERBARIUM—PRETORIA (RHEN)

Koekemoer, Ms M. Ph.D. Deputy Director. Herbarium management. Taxonomy of Asteraceae: Gnaphalieae

Bredenkamp, Mrs C.L. Ph.D. Principal Agricultural Scientist. Assistant Curator: Public relations. Taxonomy of *Vitex*, *Phylica,* Rhamnaceae, Sterculiaceae and other related families
Herman, P.P.J. M.Sc. Principal Agricultural Scientist. Assistant Curator: Personnel. Taxonomy of Asteraceae, Flora of Transvaal
Mothogoane, M.S. Assistant Curator: Herbarium assistants. Wing C
Sebothoma, P.N. Cert.(Sec.). Assistant Curator: Service room. Plant identifications co-ordinator
Van Rooy, J. Ph.D. Assistant Curator: Technical staff. Taxonomy and biogeography of mosses

Anderson, J.M. Ph.D. Specialist Scientist. Palaeobotany, palaeogeography

Archer Mrs C. M.Sc. Senior Agricultural Scientist. Taxonomy of Cyperaceae, Restionaceae, Orchidaceae

Archer, R.H. Ph.D. Senior Agricultural Scientist. Taxonomy of mainly Celastraceae, Euphorbiaceae

Burgoyne, Ms P.M. M.Sc. Principal Agricultural Scientist. Mesembryanthemaceae

Fish, Mrs L. B.Sc. Principal Agricultural Scientist. Taxonomy of Poaceae. Collections manager

Glen, H.F. Ph.D. Specialist Scientist. Taxonomy of trees, herbarium for cultivated plants, and botanical collectors

Glen, Mrs R.P. M.Sc. Chief Agricultural Development Technician. Taxonomy of ferns, water plants

Götzel, Ms A. Senior Provisioning Admin. Clerk III

Jordaan, Mrs M. M.Sc. Principal Agricultural Scientist. Taxonomy of Casuarinaceae–Connaraceae, *Maytenus*

Kgaditsi, T.W. Senior Auxiliary Services Officer. Specimen mounter, general assistant

Klein, R.G. Plant Collector, Bioprospecting Project (contract worker)

Makgakga, M.C. B.Sc. Agricultural Development Technician. Herbarium Assistant, laboratory. Wing B

Makgakga, K.S. Senior Auxiliary Services Officer. Herbarium Assistant. Encoding plant specimens

Manamela, Ms M.T. B.Sc. Agricultural Development Technician. Information Officer

Maserumule, M.K. Auxiliary Services Officer I. Wing B

Masombuka, Ms A.S. N.Dip.(Nature Cons.). Senior Auxiliary Services Officer. Herbarium Assistant. Wing A

Meyer, J.J. H.E.D. Chief Agricultural Development Technician. Bioprospecting Project

Mmakola, E.K. Data Capturer (SABONET contract worker)

Mothapo, M.A. Data Capturer (SABONET contract worker)

Nkoane, Ms G.K. Senior Auxiliary Services Officer. Loans, exchanges, parcelling, stores

Nkonki, Mrs T. B.Sc. Senior Agricultural Development Technician. Fabaceae taxonomy. Wing B

Nkuna, L.A. Agricultural Development Technician. Kew Millenium Seed Bank Project (contract worker)

Perold, Mrs S.M. Ph.D. Taxonomy of Hepaticae (contract worker)

Phahla, T.J. Senior Auxiliary Services Officer. Specimen mounter of cryptogams, packer

Ready, Mrs J.A. N.Dip.(Hort.). Principal Auxiliary Services Officer. Plant identifications, *Helichrysum*. Wing D

Rampho, Ms E.T. Data Quality Controller (SABONET contract worker)

Retief, Miss E. M.Sc. Principal Agricultural Scientist. Taxonomy of Boraginaceae, Verbenaceae, Lamiaceae, Asteraceae, Rubiaceae

Smithies, Mrs S.J. M.Sc., Dip.Ed.(Moray House). Chief Agricultural Development Technician. Taxonomy of Scrophulariaceae, Selaginaceae, Lobeliaceae

Steyn, Ms C.C. Principal Auxiliary Services Officer. Label typist, service room support

Van Wyk, E. M.Sc. Agricultural Development Technician. Seedbank Manager, Kew Millenium Seedbank Project (contract worker)

Victor, Ms J.E. M.Sc., H.Dip.(Journ.). Principal Agricultural Scientist. Taxonomy of Rutaceae, Asclepiadaceae

Welman, Ms W.G. M.Sc. Principal Agricultural Scientist. Taxonomy of Convolvulaceae, Solanaceae, Cucurbitaceae, Campanulaceae, Asteraceae, Acanthaceae

DATA MANAGEMENT—PRETORIA (RPDC)

Arnold, T.H. M.Sc. Assistant Director. Computer database application especially in taxonomy

Botha, Mrs A.G. Chief Auxiliary Services Officer. Administrative Assistant

De Wet, Mrs B.C. B.Sc.(Computer Science), B.A., H.D.L.S. Principal Agricultural Datametrician

Neveling, Mrs V.H. Principal Typist I

Smit, G.C. NT Workstation 4, NT Server 4. Principal Network Controller

Snyman, Mrs E.E. B.Sc. N.Dip.(Comp. Data Proc.). Senior Agricultural Development Technician

Steyn, Ms H.M. Botanical Information Officer (contract worker)

Swelankomo, Ms N. Agricultural Development Technician. Quality control

SABONET—PRETORIA (YSGE/IS)

Siebert, S.J. Ph.D. Regional Co-ordinator (contract worker)

Davis, Ms L.F. Senior State Accountant (part time contract worker)

Klopper, Ms R. M.Sc. Technician (contract worker)

Mössmer, Ms M. B.Sc.(Hons). Publications and Website Management (contract worker)

Noko, Ms N.R. Admin. Officer (contract worker)

ECOLOGY AND CONSERVATION SUBDIRECTORATE (RREL)

CAPE TOWN

Rutherford, M.C. Ph.D., Dip.(Datamet.). Deputy Director: Research

Morkel, Ms L. N.Dip.(Office Admin.). Senior Provisioning Admin. Clerk III. Personal Assistant to Deputy Director: Research

Parenzee, Ms H.A. Dip.(Ed.). Senior Provisioning Admin. Clerk III

Powrie, L.W. M.Sc. Chief Information Technology Advisor. Spatial modelling, databases

CLIMATE CHANGE

Rutherford, M.C. Ph.D., Dip.(Datamet.). Chief Specialist Scientist.
Modelling, global change

Arnolds, Ms J.L. Chief Auxiliary Services Officer. Laboratory
Kgope, B.S. M.Sc. Senior Agricultural Scientist. Plant ecophysiology
Midgley, G.F. Ph.D. Principal Specialist Scientist. Plant ecophysiology, modelling
Millar, Ms D.L. M.Sc. Research Co-ordinator (contract worker)
Motete, Ms N. B.Sc.(Bot. & Ed.), M.Sc.(Envir. Biol.), Dip.(Science Ed.). Senior Agricultural Scientist
Musil, C.F. Ph.D. Senior Specialist Scientist. Ecophysiology, modelling
Snyders, S.G. Senior Auxiliary Services Officer II. Greenhouse, maintenance

CONSERVATION BIOLOGY

Donaldson, J.S. Ph.D.(Zoology) Principal Specialist Scientist.
Supervisor: Conservation farming. Cycad biology

Bösenberg, J. de Wet. B.Sc.(Hons). Chief Agricultural Development Technician. Cycad biology, Conservation farming
Ebrahim, I. N.Dip.(Hort.). Assistant. Protea Atlas Project (contract worker)
Marinus, E.M. N.Cert.(Building & Structures). Chief Auxilliary Services Officer. Conservation farming
Rebelo, A.G. Ph.D.(Zoology). Principal Agricultural Scientist. Protea Atlas Project
Smit, W.J. M.A. Geographic Information Assistant. Protea Atlas Project (contract worker)

CONSERVATION FARMING PROJECT

Nänni, Ms I. B.Sc., H.E.D. Control Agricultural Development Technician.
Project Co-ordinator

Breebaart, Ms L. M.Sc.(Range and Forage Resources). Researcher. Production benefits of different grazing systems (Nama Karoo) (contract worker)
Leonhart, Ms A. N.Dip.(Nature Cons.). Research Assistant. Assessments of biodiversity and ecosystem services (contract worker)
Segers, Ms A. Senior Provisioning Admin. Clerk III (contract worker)
Skowno, A. M.Sc. Research Officer. Biodiversity risk analysis in farm landscapes (contract worker)
Theron, L.J. M.Sc.(Zoology). Research Assistant (contract worker)

DESERTIFICATION

Petersen, Ms A. B.Sc.(Hons). Senior Agricultural Development Technician.
Land use and vegetation mapping

HORTICULTURAL RESEARCH

Brown, N.A.C. Ph.D. Specialist Scientist. Seed research

INFORMATION TECHNOLOGY (SOUTH) (RRIT)

Evans, N. Control Network Controller. Technical IT Manager
Pekeur, Ms B.L. IT Admin. Clerk (contract worker)

SUPPORT SERVICES

Bardien-Overmeyer, Ms S. B.A.(Pharm.). Senior Provisioning Admin. Officer. Admin. Manager

Bowler, Mrs M. Specialist Cleaner. Assistant: teas and functions
De Witt, D.M. Senior Artisan. Maintenance

HARRY MOLTENO LIBRARY (RRLC)

Jagger, B.W. B.A.(Soc. Sc.), PGDip.Lis. Librarian
Ovens, Ms C.S.H. Ph.D.(Inf.Sc.), Dip.Datametrics. (contract librarian)

NBI WEBSITES (AMWS)

Reynolds, Ms P.Y. M.A.(Inf.Sc.), B.Proc., Dip.Datametrics. Principal Librarian.
NBI Web Site Manager

PUBLICATIONS BY THE STAFF

1 April 2002–31 March 2003

ARCHER, C. 2002. Review: Bulbs. Revised edition by John E. Bryan, 2002. *Bothalia* 32: 251, 252.

ARCHER, C. & VICTOR, J.E. 2002. Cyperaceae. In J.S. Golding, *Southern African plant Red Data Lists*: 100, 111, 112, 119. Southern African Botanical Diversity Network Report No. 14.

ARNOLD, T.H. & SIEBERT, S. 2002. Computerisation of southern African Herbaria: regional update. *SABONET News* 7: 92–96.

AUBREY, A. 2003-01. *Pterocarpus angolensis* DC. (Fabaceae). Internet 3 pp. http://www.plantzafrica.com/plantnop/pterocarpangol.htm.

AUBREY, A. & LETSELA, M. 2002-04. *Dovyalis zeyheri* (Sond.) Warb. (Flacourtiaceae). Internet 3 pp. http://www.plantzafrica.com/plantcd/dovyaliszeyher.htm.

BAIJNATH, H. & SINGH, Y. (eds). 2002. *Rebirth of science in Africa. A shared vision for life and environmental sciences.* Umdaus Press, Hatfield, Pretoria.

BARKER, N.P., WESTON, P.H., ROURKE, J.P. & REEVES, G. 2002. The relationships of the southern African Proteaceae as elucidated by internal transcribed spacer (ITS) DNA sequence data. *Kew Bulletin* 57: 867–883.

BEHR, K. 2003-01. *Leucospermum saxosum* S.Moore (Proteaceae). Internet 2 pp. http://www.plantzafrica.com/plantklm/leucospermsax.htm.

BEYERS, J.B.P. 2002a. A new species of *Gnidia* from the Knersvlakte, Western Cape, South Africa (Thymelaeaceae). *Bothalia* 32: 79–81.

BEYERS, J.B.P. 2002b. Reduction of *Foveolina albida* to *Foveolina dichotoma* (Asteraceae–Anthemideae). *Bothalia* 32: 185.

BEYERS, J.B.P. 2002c. A new species of *Arctotheca* from northern Cape, South Africa (Asteraceae). *Bothalia* 32: 185–187.

BEYERS, J.B.P., BREDENKAMP, C.L. & VICTOR, J.E. 2002. Thymelaeaceae. In J.S. Golding, *Southern African plant Red Data Lists*: 105, 116, 117, 120. Southern African Botanical Diversity Network Report No. 14.

BEZUIDENHOUT, K. & GLEN, H. 2002. Editorial introduction. *De Nummis* 5: 5.

BREDENKAMP, C.L. & VAN WYK, A.E. 2002a. Abstract: Monograph of the genus *Passerina* L. (Thymelaeaceae). 28th Annual Congress of the SA Association of Botanists held at Rhodes University, Grahamstown, 13–16 January 2002. *South African Journal of Botany* 68: 245.

BREDENKAMP, C.L. & VAN WYK, A.E. 2002b. *Passerina quadrifaria* (Thymelaeaceae): a new species from the southern Cape and Little Karoo in South Africa. *South African Journal of Botany* 68: 304–307.

BREDENKAMP, C.L. & VAN WYK, A.E. 2002c. Taxonomy of the *Passerina filiformis* complex (Thymelaeaceae). *Bothalia* 32: 29–36.

BREDENKAMP, C.L. & VAN WYK, A.E. 2002d. Systematics of *Passerina truncata* and a new subspecies *monticola* (Thymelaeaceae). *Bothalia* 32: 65–71.

BREDENKAMP, C.L. & VAN WYK, A.E. 2002e. A new species of *Passerina* from Western Cape, South Africa (Thymelaeaceae). *Bothalia* 32: 76–79.

BROWN, N. & BOTHA, P. 2002. Smoking seeds. An updated list of fynbos species with seeds that have a good germination response to smoke. *Veld & Flora* 88: 68, 69.

BURGOYNE, P.M. & PILLAY, N. 2002. Abstract: Pollination of *Cytinus visserii*—the northern-most species of this Cape-centred genus. 28th Annual Congress of the SA Association of Botanists held at Rhodes University, Grahamstown, 13–16 January 2002. *South African Journal of Botany* 68: 246.

BUYS, M.H., BURGOYNE, P. & TIEDT, L.R. 2002. Abstract: Palynology and the *Stomatium* group in the Aizoaceae. 28th Annual Congress of the SA Association of Botanists held at Rhodes University, Grahamstown, 13–16 January 2002. *South African Journal of Botany* 68: 246.

CAFFERTY, S., OLIVER, E.G.H. & OLIVER, I. 2002. (1561–1563) Proposals to conserve the names *Erica calycina*, *E. corifolia*, and *E. imbricata* (Ericaceae) with conserved types. *Taxon* 51: 810–812.

CAROLUS, B. 2002. Threatened plants programmes. *SABONET News* 7: 131–133.

CAROLUS, B. 2002-11. *Aloe plicatilis* (L.) Mill. (Asphodelaceae). Internet 2 pp. http://www.plantzafrica.com/plantab/aloeplicatilis.htm.

CAROLUS, B. 2002-11. *Phylica buxifolia* L. (Rhamnaceae). Internet 2 pp. http://www.plantzafrica.com/plantnop/phylicabux.htm.

CAROLUS, B. 2002-11. *Psoralea pinnata* L. (Fabaceae). Internet 2 pp. http://www.plantzafrica.com/plantklm/psoraleapin.htm.

CAROLUS, B. 2002-11. *Struthiola myrsinites* Lam. (Thymelaeaceae). Internet 2 pp. http://www.plantzafrica.com/plantqrs/struthiolmyrsin.htm.

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WILLIS, C.K. 2002h. New name for Karoo Garden. *Botanic Gardens Conservation News* 3,8: 11, 12.

WILLIS, C.K. 2002i. Conservation collections in South Africa's National Botanical Gardens. *Botanic Gardens Conservation News* 3,9: 7, 8.

WILLIS, C.K. 2002j. Plant Conservation Workshop in Durban. *Botanic Gardens Conservation News* 3,9: 8, 9.

WILLIS, C.K. 2003. African Botanic Gardens Network launched. *BioNET-International News* 13: 8.

WILLIS, C.K., BURROWS, J.E., FISH, L., PHIRI, P.S.M., CHIKUNI, A.C. & GOLDING, J. 2002 (2001). Developing a greater understanding of the flora of the Nyika. *Systematics and Geography of Plants* 71: 993–1008.

WILLIS, C.K. & DALZELL, C. 2002. SABONET Horticultural Course. *SABONET News* 7: 117, 118.

WILLIS, C.K., DALZELL, C. & OWUSU-AFRIYIE, G. 2002. Launch of the African Botanic Gardens Network. *Botanic Gardens Conservation News* 3,9: 35–38.

WILLIS, C.K. & DENNIS, F. 2002. 2nd Congress Steering Committee Meeting, Aburi, Ghana. *African Botanic Gardens Network Bulletin* 5: 1. Botanic Gardens Conservation International, Richmond, UK.

WILLIS, C.K. & HUNTLEY, B.J. 2002 (2001). SABONET: developing capacity within southern Africa's herbaria and botanical gardens. *Systematics and Geography of Plants* 71: 247–258.

WILLIS, C.K., SIEBERT, S. & DALZELL, C. 2002. Regional course for southern African horticulturists. *African Botanic Gardens Network Bulletin* 5: 4. Botanic Gardens Conservation International, Richmond, UK.

WILLIS, C.K. & SMITH, G.F. 2002. Canary Islands: land of the dragon trees. *Aloe* 39: 15–22.

WINTER, J. 2002. Growing and propagating *Clivia mirabilis*. *Clivia Four*: 13. Clivia Society, Cape Town.

Bothalia 33,2: 245–254 (2003)

Guide for authors to *Bothalia*

This guide is updated when necessary and includes an index. **Important points and latest additions appear in bold type**.

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the National Botanical Institute, Pretoria, is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

1 Editorial policy

1.1 *Bothalia* welcomes original papers dealing with flora and vegetation of southern Africa and related subjects. Full-length papers and short notes, as well as book reviews and obituaries of botanists, are accepted. The editor should be notified that an article is part of a series of manuscripts; please submit a list of the parts of a series; all parts should preferably be published in one journal.

1.2 Submission of a manuscript to *Bothalia* implies that it has not been published previously and is not being considered for publication elsewhere.

1.3 Authors whose first language is not English are requested to have their MS edited by an English speaker before submission.

1.4 Articles are assessed by referees, both local and overseas. Authors are welcome to suggest possible referees to judge their work. Authors are responsible for the factual correctness of their contributions. *Bothalia* maintains an editorial board (see title page) to ensure that international standards are upheld.

1.5 **Page charges**: as stated in our notification included in volume 23,1 (May 1993), MSS submitted for publication in *Bothalia* are subject to payment of page charges of R125,00 per printed page, VAT included. The following are exempt from these charges: 1, NBI members; 2, persons/institutions who have been granted exemption by the Executive Committee of the NBI; 3, authors of contributions requested by the Editor; 4, contributors to the column '*FSA* contributions'. The Editor's decision on the number of pages is final. An invoice will be sent to the author, who must arrange for payment as soon as possible to NBI, Publications Section, Private Bag X101, Pretoria 0001.

1.6 Deadline dates for submission of MS: for possible inclusion of the MS for the May issue—August of the previous year, and for the October issue—March of the same year.

2 **Requirements for a manuscript**

2.1 The original manuscript should be typed on one side of A4-size paper, double line spacing throughout (including abstract, tables, captions to figures, literature references, etc.) and have a margin of at least 30 mm all round. Three photocopies (all pages photocopied on both sides of the paper, including figures, to reduce weight for postage) of all items, including text, line drawings, tables and lists should be submitted, and the author should retain a complete set of copies. Three photographs (or high quality photocopies) of each photograph/photograph mosaic should be submitted for review purposes. The electronic version should be submitted with the final (accepted) manuscript (see 3).

2.2 Papers should conform to the general style and layout of recent issues of *Bothalia* (from volume 26 onwards).

2.3 Material should be presented in the following sequence: Title page with title, name(s) of author(s), keywords, abstract (and information that should be placed in a footnote on the title page, such as address(es) of author(s) and mention of granting agencies).

2.4 The sequence continues with Introduction and aims, Contents (see 8), Material and methods, Results, Interpretation (Discussion), Specimens examined (in revisions and monographs), Acknowledgements, References, Index of names (recommended for revisions dealing with more than about 15 species), Tables, Captions for figures and figures. In the case of short notes, obituaries and book reviews, keywords and an abstract are superfluous.

2.5 All pages must be numbered consecutively beginning with the title page to those with references, tables, captions for figures and figures.

2.6 Special characters: use your own word or code that is unique and self-explanatory, enclosed between ANGLE BRACKETS, e.g. <mu>m for µm. Please supply us with a list of the codes.

2.7 Use a non-breaking space (in MS Word—Ctrl, shift, space) to keep two elements together on the same line, e.g. 3 500.

2.8 DO NOT JUSTIFY LINES.

2.9 Do not break words, except hyphenated words.

2.10 A **hyphen** is designated as one dash, with no space between the letter and the dash, e.g. ovate-lanceolate. See also 17.6.

2.11 An **N-dash** is typed in MS Word code (alt + 0150) or as **three** hyphens with no space between the letter and the hyphen, e.g. 2- - -5 mm (typeset, it looks like this, 2–5 mm).

2.12 An **M-dash** is typed in MS Word code (alt + 0151) or as **two** hyphens with no space between the letter and the hyphen, e.g. computers- -what a blessing! (typeset, it looks like this: computers—what).

2.13 Do not use a double space anywhere between words, after commas, full stops, colons, semicolons or exclamation marks.

2.14 Use lower case x as times sign, with one space on either side of the x, e.g. 2 x 3 mm.

2.15 Use single (not double) opening and closing quotes, e.g. the so-called 'stiffy' refers to a rigid diskette.

2.16 Keys—put only three leader dots before number of taxon (with one space before and after each dot), regardless of how far or near the word is from the right margin, e.g. . . . 1. *R. ovata* (see 13.18).

3 Requirements for diskettes/stiffies/image files

(text to be submitted only with final/accepted version)

3.1 **USE NORMAL STYLE ONLY.**

3.2 Electronic files can be provided on 1.4 MB stiffie disks, Iomega zip diskettes, 640 MB optical disks for Apple Mac or on CD.

3.3 Data must be IBM compatible and written in ASCII, or in Word 97 for Windows 95/98. An rtf file is preferable because it retains the formatting.

3.4 All lines, headings, keys, etc., should start flush at the margin, therefore NO INDENTATIONS, FOOTNOTES, TABS OR STYLES of any kind.

3.5 In MS Word, italics and bold should be used where necessary.

3.6 Paragraphs and headings are delineated by a carriage return (ENTER) but **no indentation**.

3.7 **Graphics i.e. drawings, graphs or photographs: submit in a separate file, do not include it in the text.**

3.8 Image files with a bigger file size than 1MB cannot be e-mailed as the NBI has a 1MB limitation on the network's firewall at Head Office. Files smaller than 1MB can be emailed to: bmomberg@nbipre.nbi.ac.za.

3.9 If any image file was originated in CorelDraw versions 3–9, please provide the image file as a CDR file (please include fonts). The conversion to TIF or other file extensions will be accommodated by the NBI (see 12.2–12.4).

3.10 If extensive changes to image files are proposed by the editor, the author will be contacted and the specific image file will have to be re-submitted after the indicated corrections have been implemented.

3.11 **Tracked changes must not be included when submitting a MS on diskette or electronically.**

4 Author(s)

When there are several authors, the covering letter should indicate clearly which of them is responsible for correspondence and, if possible, telephonically available while the article is being processed. The contact address and telephone number should be mentioned if they differ from those given on the letterhead.

5 Title

The title should be as concise and as informative as possible. In articles dealing with taxonomy or closely related subjects, the family of the taxon under discussion (see also 13.2) should be mentioned in brackets but author citations should be omitted from plant names (see also 13.6).

6 Keywords

Up to 10 keywords (or index terms) should be provided in English in alphabetical sequence. The following points should be borne in mind when selecting keywords:

6.1 Keywords should be unambiguous, internationally acceptable words and not recently coined little-known words.

6.2 They should be in a noun form and verbs should be avoided.

6.3 They should not consist of an adjective alone; adjectives should be combined with nouns.

6.4 They should not contain prepositions.

6.5 The singular form should be used for processes and properties, e.g. evaporation.

6.6 The plural form should be used for physical objects, e.g. augers.

6.7 **Location** (province and/or country); taxa (species, genus, family) and vegetation type (community, veld type, biome) should be used as keywords.

6.8 Keywords should be selected hierarchically where possible, e.g. both family and species should be included.

6.9 They should include terms used in the title.

6.10 They should answer the following questions:

6.10.1 What is the *active concept* in the document (activity, operation or process).

6.10.2 What is the *passive concept* or object of the active process (item on which the activity, operation or process takes place).

6.10.3 What is the means of accomplishment or how is the active concept achieved (technique, method, apparatus, operation or process).

6.10.4 What is the environment in which the active concept takes place (medium, location).

6.10.5 What are the independent (controlled) and dependent variables?

6.11 Questions 6.10.1 to 6.10.3 should preferably also be answered in the title.

7 Abstract

7.1 Abstracts of no more than 200 words should be provided. Abstracts are of great importance and should convey the essence of the article.

7.2 They should refer to the geographical area concerned and, in taxonomic articles, mention the number of taxa treated. They should not contain information not appearing in the article.

7.3 In articles dealing with taxonomy or closely related subjects all taxa from the rank of genus downwards should be accompanied by their author citations (see also 13.6).

7.4 Names of new taxa and new combinations should not be italicized but put in bold. If the article deals with too many taxa, only the important ones should be mentioned.

8 **Table of contents**

A table of contents should be given for all articles longer than about 60 typed pages, unless they follow the strict format of a taxonomic revision.

9 **Acknowledgements**

Acknowledgements should be kept to the minimum compatible with the requirements of courtesy. Please give all the initials of the person(s) you are thanking.

10 **Literature references**

In text

10.1 Literature references in the text should be cited as follows: 'Jones & Smith (1986) stated...', or '...(Jones & Smith 1986)' or (Ellis 1988: 67) when giving a reference simply as authority for a statement. For treatment of literature references in taxonomic papers see 14.

10.2 When more than two authors are involved in the paper, use the name of the first author followed by *et al.*

10.3 When referring to more than one literature reference, they should be arranged chronologically and separated by a semicolon, e.g. (Nixon 1940; Davis 1976; Anon. 1981, 1984).

10.4 Titles of books and names of journals should preferably not be mentioned in the text. If there is good reason for doing so, they should be treated as described in 10.12 & 10.13.

10.5 Personal communications are given only in the text, not in the list of references. Please add the person's full initials to identify the person more positively, e.g. C. Boucher pers. comm.

In References at end of article

10.6 References of the same author are arranged in chronological sequence.

10.7 Where two or more references by the same author are listed in succession, the author's name is repeated with every reference, except in an obituary, where the name of the deceased in the list of publications (not in the references) is replaced by an N-dash.

10.8 All publications referred to in the text, including those mentioned in full in the treatment of correct names in taxonomic papers, but no others, and no personal communications, are listed at the end of the manuscript under the heading References.

10.9 The references are arranged alphabetically according to authors and chronologically under each author, with a, b, c, etc. added to the year, if the author has published more than one work in a year. This sequence is retained when used in the text, irrespective of the chronology.

10.10 If an author has published both on his own and as a senior author with others, the solo publications are listed first and after that, in strict alphabetical sequence, those published with one or more other authors.

10.11 Author names are typed in capitals.

10.12 Titles of journals and of books are written out in full and are italicized as follows: *Transactions of the Linnean Society of London* 5: 171–217, or *Biology and ecology of weeds*: 24.

10.13 Titles of books should be given as in *Taxonomic literature*, edn 2 by Stafleu & Cowan and names of journals as in the latest edition of *World list of scientific periodicals*.

10.14 Examples of references:

Collective book or Flora

BROWN, N.E. 1909. Asclepiadaceae. In W.T. Thiselton-Dyer, *Flora capensis* 6,2: 518–1036. Reeve, London.

CUNNINGHAM, A.B. 1994. Combining skills: participatory approaches in biodiversity conservation. In B.J. Huntley, Botanical diversity in southern Africa. *Strelitzia* 1: 149–167. National Botanical Institute, Pretoria.

Book

DU TOIT, A.L. 1966. *Geology of South Africa*, edn 3, S.M. Haughton (ed.). Oliver & Boyd, London.

HUTCHINSON, J. 1946. *A botanist in southern Africa*. Gawthorn, London.

Journal

DAVIS, G. 1988. Description of a proteoid-restioid stand in Mesic Mountain Fynbos of the southwestern Cape and some aspects of its ecology. *Bothalia* 18: 279–287.

SMOOK, L. & GIBBS RUSSELL, G.E. 1985. Poaceae. *Memoirs of the Botanical Survey of South Africa* No. 51: 45–70.

STEBBINS, G.L. Jr 1952. Aridity as a stimulus to plant evolution. *American Naturalist* 86: 35–44.

In press, in preparation

TAYLOR, H.C. in press. *A reconnaissance of the vegetation of Rooiberg State Forest*. Technical Bulletin, Department of Forestry.

VOGEL, J.C. 1982. *The age of the the Kuiseb river silt terrace at Homeb. Palaeoecology of Africa* 15. In press.

WEISSER, P.J., GARLAND, J.F. & DREWS, B.K. in prep. Dune advancement 1937–1977 and preliminary vegetation succession chronology at Mlalazi Nature Reserve, Natal, South Africa. *Bothalia*.

Thesis

KRUGER, F.J. 1974. *The physiography and plant communities of the Jakkalsrivier Catchment*. M.Sc. (Forestry) thesis, University of Stellenbosch.

MUNDAY, J. 1980. *The genus* Monechma *Hochst. (Acanthaceae tribe Justiciae) in southern Africa*. M.Sc. thesis, University of the Witwatersrand, Johannesburg.

Miscellaneous paper, report, unpublished article, technical note, congress proceedings

ANON. no date. *Eetbare plante van die Wolkberg*. Botanical Research Unit, Grahamstown. Unpublished.

BAWDEN, M.G. & CARROL, D.M. 1968. *The land resources of Lesotho*. Land Resources Study No. 3, Land Resources Division, Directorate of Overseas Surveys, Tolworth.

BOUCHER, C. 1981. Contributions of the Botanical Research Institute. In A.E.F. Heydorn, *Proceedings of workshop research in Cape estuaries*: 105–107. National Research Institute for Oceanology, CSIR, Stellenbosch.

NATIONAL BUILDING RESEARCH INSTITUTE 1959. *Report of the committee on the protection of building timbers in South Africa against termites, woodboring beetles and fungi*, edn 2. CSIR Research Report No. 169.

11 Tables (also digital submissions)

11.1 Each table should be presented on a separate sheet and be assigned an Arabic numeral, i.e. the first table mentioned in the text is marked 'Table 1'.

11.2 In the captions of tables the word 'TABLE' is written in capital letters. See recent numbers of *Bothalia* for the format required.

11.3 Avoid vertical lines, if at all possible. Tables can often be reduced in width by interchanging primary horizontal and vertical heads.

12 Figures (also digital submissions)

12.1 Figures should be planned to fit, after reduction, into a width of either 80, 118 or 165 mm, with a maximum vertical length of 230 mm. Allow space for the caption in the case of figures that will occupy a whole page.

12.2 Line drawings (artwork) should be twice the size of the final reproduction and should be in jet-black Indian ink, preferably on fine Schoellers Hammer Parole or similar paper, 200 gsm, or tracing film. Lines should be bold enough and letters/symbols large enough to stand reduction. If submitted electronically, provide each drawing as a separate TIF, BMP or JPG file at 600 dots per inch (dpi) and a hard copy of the figure.

12.3 Graphs and histograms should be submitted as XLS files if from Word version 6. If the files were generated in later versions of Excel or in other software programmes, export them as TIF or JPG files.

12.4 Photographs should be of excellent quality on glossy paper with clear detail and moderate contrast, and they should be the same size as required in the journal. If submitted electronically, provide as a TIF, BMP or JPG file at 300 dpi and not as a doc file. Include a hard copy of good quality.

12.5 Photograph mosaics should be submitted complete, the component photographs mounted neatly on a white flexible card base (can be curved around drum of scanner) leaving a narrow gap of uniform width (2 mm) between each print. Note that grouping photographs of markedly divergent contrast results in poor reproductions.

12.6 Lettering on photograph mosaics, in capital letters, should be put on a small white disk ± 7 mm in diameter, if the background is dark, and placed in the lower left hand corner of the relevant photo.

12.7 If several illustrations are treated as components of a single composite figure they should be designated by capital letters.

12.8 Note that the word 'Figure' should be written out in full, both in the text and the captions and should begin with a capital 'F' (but see 14.7 for taxonomic papers).

12.9 In the text the figure reference is then written as in the following example: 'The stamens (Figure 4A, B) are...'

12.10 In captions, 'FIGURE' is written in capital letters. Magnification of figures should be given for the size as submitted.

12.11 Scale bars or scale lines should be used on figures.

12.12 In figures accompanying taxonomic papers, voucher specimens should be given in the relevant caption.

12.13 Figures are numbered consecutively with Arabic numerals in the order they are referred to in the text. These numbers, as well as the author's name and an indication of the top of the figure, must be written in soft pencil on the back of all figures.

12.14 Captions of figures must not be pasted under the photograph or drawing and must also not be included in any electronic version of the figures.

12.15 Captions for figures should be collected together and typed at the end of the MS and headed *Captions for figures*.

12.16 Authors should indicate in pencil in the text where they would like the figures to appear.

12.17 Authors wishing to have the originals of figures returned must inform the editor in the original covering letter and must mark each original 'To be returned to author'.

12.18 Authors wishing to use illustrations already published elsewhere must obtain written permission before submitting the manuscript and inform the editor of this fact.

12.19 It is strongly recommended that taxonomic articles include dot maps as figures to show the distribution of taxa. The dots used must be large enough to stand reduction to 80 mm (recommended size: 5 mm diameter).

12.20 Blank distribution maps of southern Africa, Africa and the world are available from the Bookshop, NBI Pretoria.

12.21 A dot map PC programme for distribution of taxa in South Africa, called MAPPIT is available for purchase from the Data Section, National Botanical Institute, Pretoria.

12.22 ArcView GIS maps are acceptable. The layout representing all the appropriate themes (including grid lines) should be exported as a Postscript New (EPS) file at 600 dpi.

12.23 Colour figures are permitted only if: a) it will clarify the article and b) the cost of reproduction and printing is borne by the author.

13 Text

13.1 As a rule, authors should use the plant names (but not of all authors of plant names—see 13.6) as listed in PRECIS (National Herbarium **PRE**toria **C**omputerised **I**nformation **S**ystem).

13.2 Names of genera and infrageneric taxa are usually italicized, with the author citation (where relevant; see 13.6) not italicized. Exceptions include names of new taxa in the abstract, correct names given in the synopsis or in paragraphs on species excluded from a given supraspecific group in taxonomic articles; in checklists and in indices, where the position is reversed, correct names are not italicized and synonyms are italicized.

13.3 Names above generic level are not italicized.

13.4 In articles dealing with taxonomy, the complete scientific name of a plant (with author citation) should be given at the first mention in the text. The generic name should be abbreviated to the initial thereafter, except where intervening references to other genera with the same initial could cause confusion (see 16.6).

13.5 In normal text, Latin words are italicized, but in the synopsis of a species, Latin words such as *nom. nud.* and *et al.* are not italicized (see 16.4, 17.9).

13.6 In accordance with Garnock-Jones & Webb (1996) in *Taxon* 45: 285, 286, authors of plant names are not to be added to plant names except in taxonomic papers. Names of authors of plant names should agree with the list published by the Royal Botanic Gardens, Kew, entitled, *Authors of plant names*, edited by R.K. Brummitt & C.E. Powell (1992).

13.7 Modern authors not included in the list should use their full name and initials when publishing new plant names. Other author names not in the list should be in agreement with the recommendations of the Code.

13.8 Names of authors of publications are written out in full, without initials, except in the synonymy in taxonomic articles where they are treated like names of authors of plant names.

13.9 Names of plant collectors are italicized whenever they are linked to the number of a specimen. The collection number is also italicized, e.g. *Acocks 14407*.

13.10 Surnames beginning with 'De', 'Du' or 'Van' begin with a capital letter unless preceded by an initial.

13.11 For measurements use only units of the International System of Units (SI). **In taxonomic papers only mm and m, should be used; in ecological papers cm or m should be used**.

13.12 The use of '±' is preferred to c. or ca (see 17.7).

13.13 Numbers 'one' to 'nine' are spelt out in normal text, and from 10 onwards they are written in Arabic numerals.

13.14 In descriptions of plants, numerals are used throughout. Write 2.0–4.5 (not 2–4.5) and 2.0–4.5 × 6–9. When counting members write 2 or 3 (not 2–3), but 2–4.

13.15 Abbreviations should be used sparingly but consistently. No full stops are placed after abbreviations ending with the last letter of the full word (e.g. edition = edn; editor = ed.); after units of measure; after compass directions; after herbarium designations; after countries, e.g. USA and after well-known institutions, e.g. CSIR.

13.16 Apart from multi-access keys, indented keys should be used with couplets numbered 1a–1b, 2a–2b, etc. (without full stops thereafter).

13.17 Keys consisting of a single couplet have no numbering.

13.18 Manuscripts of keys should be presented as in the following example:

1a Leaves closely arranged on elongated stem; a submerged aquatic with only capitula exserted . . . 1b. *E. setaceum* var. *pumilum*

1b Leaves in basal rosettes; stems suppressed; small marsh plants, ruderals or rarely aquatics:

2a Annuals, small, fast-growing pioneers, dying when habitat dries up; capitula without coarse white setae; receptacles cylindrical:

3a Anthers white . . . 2. *E. cinereum*

3b Anthers black . . . 3. *E. nigrum*

2b Perennials, more robust plants; capitula sparsely to densely covered with short setae:

13.19 Herbarium voucher specimens should be referred to wherever possible, not only in taxonomic articles.

13.20 The word Figure should be written out in full and should begin with a capital F, also in captions where the whole word is in capital letters (see 12.8–12.10).

14 Species treatment in taxonomic papers

14.1 The procedure to be followed is illustrated in the example (17.9), which should be referred to, because not all steps are described in full detail.

14.2 The correct name (bold, not italicized) is to be followed by its author citation (italicized) and the full literature reference, with the name of the publication written out in full (not italicized).

14.3 Thereafter all literature references, including those of the synonyms, should only reflect author, page and year of publication, e.g. C.E.Hubb. in Kew Bulletin 15: 307 (1960); Boris et al.: 14 (1966); Boris: 89 (1967); Sims: t. 38 (1977); Sims: 67 (1980).

14.4 The description and the discussion should consist of paragraphs commencing, where possible, with italicized leader words such as *flowering time*, *etymology*, *diagnostic characters*, *distribution* and *habitat,* **with a colon following the leader word and the first word of the sentence beginning with a lower case letter.**

14.5 When more than one species of a given genus is dealt with in a paper, the correct name of each species should be prefixed by a sequential number followed by a full stop. Infraspecific taxa are marked with small letters, e.g. 1b., 12c., etc.

14.6 Names of authors are written as in 13.6, irrespective of whether the person in question is cited as the author of a plant name or of a publication.

14.7 The word 'figure' is written as 'fig.', and 't.' is used for both 'plate' and 'tablet' (but see 12.8 for normal text).

14.8 Literature references providing good illustrations of the species in question may be cited in a paragraph commencing with the word Illustrations followed by a colon. This paragraph is given after the last paragraph of the synonymy, see 17.9.

14.9 When new combinations are made, the full literature reference must be given for the basionym, e.g.:

Antimima saturata (*L.Bolus*) *H.E.K. Hartmann*, comb. nov.

Ruschia saturata L.Bolus in Notes on Mesembrianthemum and allied genera, part 2: 122 (1929). *Mesembryanthemum atrocinctum* N.E.Br.: 32 (1930). Type: *Pillans BOL18952* (BOL, holo.!).

15 Citation of specimens

15.1 Type specimen in synopsis: the following should be given (if available): country (if not in RSA), province, grid reference (at least for new taxa), locality as given by original collector, modern equivalent of collecting locality in square brackets (if relevant, e.g. Port Natal [now Durban]), quarter-degree square, date of collection (optional), collector's name and collecting number (both italicized).

15.2 The abbreviation s.n. (*sine numero*) is given after the name of a collector who usually assigned numbers to his collections but did not do so in the specimen in question (see 15.11), or the herbarium number can then be cited with no space between the herbarium and its number e.g. *Marloth SAM691* (see 17.9). The herbaria in which the relevant type(s) are housed are indicated by means of the abbreviations given in the latest edition of *Index Herbariorum*.

15.3 The holotype (holo.) and its location are mentioned first, followed by a semicolon, the other herbaria are arranged alphabetically, separated by commas.

15.4 Authors should indicate by means of an exclamation mark (!) which of the types have been personally examined.

15.5 If only a photograph or microfiche was seen, write as follows: *Anon. 422* (X, holo.–BOL, photo.!).

15.6 Lectotypes or neotypes should be chosen for correct names without a holotype. It is not necessary to lectotypify synonyms.

15.7 When a lectotype or a neotype are newly chosen, this should be indicated by using the phrase 'here designated' (see 17.9). If reference is made to a previously selected lectotype or neotype, the name of the designating author and the literature reference should be given. In cases where no type was cited, and none has subsequently been nominated, this may be stated as 'not designated'.

15.8 In brief papers mentioning only a few species and a few cited specimens the specimens should be arranged according to the grid reference system: Provinces/countries (typed in capitals) should be cited in the following order: Namibia, Botswana, **Limpopo (previously Northern Transvaal, Northern Province),** North-West (previously northeastern Cape and southwestern Transvaal), Gauteng (previously PWV), Mpumalanga (previously Eastern Transvaal), Free State (previously Orange Free State), Swaziland, KwaZulu-Natal (previously Natal), Lesotho, and Northern Cape, Western Cape and Eastern Cape (Figure 1).

15.9 Grid references should be cited in numerical sequence.

15.10 Locality records for specimens should preferably be given to within a quarter-degree square. Records from the same one-degree square are given in alphabetical order, i.e (–AC) precedes (–AD), etc. Records from the same quarter-degree square are arranged alphabetically according to the collectors' names; the quarter-degree references must be repeated for each specimen cited.

15.11 The relevant international code of the herbaria in which a collection was seen should be given in brackets after the collection number; the codes are separated by commas. The following example will explain the procedure:

KWAZULU-NATAL.—2731 (Louwsburg): 16 km E of Nongoma, (–DD), *Pelser 354* (BM, K, PRE); near Dwarsrand, *Van der Merwe 4789* (BOL, M). 2829 (Harrismith): near Groothoek, (–AB), *Smith 234*; Koffiefontein, (–AB), *Taylor 720* (PRE); Cathedral Peak Forest Station, (–CC), *Marriot s.n.* (KMG); Wilgerfontein, *Roux 426*. Grid ref. unknown: Sterkstroom, *Strydom 12* (NBG).

15.12 For records from outside southern Africa authors should use degree squares without names, e.g.:

KENYA.—0136: Nairobi plains beyond race course, *Napier 485*.

15.13 Monographs and revisions: in the case of all major works of this nature it is assumed that the author has investigated the relevant material in all major herbaria and that he has provided the specimens seen with determinavit labels. It is assumed further that the author has submitted distribution maps for all relevant taxa and that the distribution has been described briefly in words in the text. Under the heading 'Vouchers' no more than five specimens should be cited, indicating merely the collector and the collector's number (both italicized). Specimens are alphabetically arranged according to collector's name. If more than one specimen by the same collector is cited, they are arranged numerically and separated by a comma. **A collector's name and the voucher number(s) is separated from the next collector by a semicolon.** The purpose of the cited specimens is not to indicate distribution but to convey the author's concept of the taxon in question.

15.14 The herbaria in which the specimens are housed are indicated by means of the abbreviation given in the latest edition of *Index Herbariorum*. They are given between brackets, arranged alphabetically and separated by commas behind every specimen as in the following example:

Vouchers: *Arnold 64* (PRE); *Fisher 840* (NH, NU, PRE); *Flanagan 831* (GRA, PRE), *840* (NH, PRE); *Marloth 4926* (PRE, STE); *Schelpe 6161, 6163, 6405* (BOL); *Schlechter 4451* (BM, BOL, GRA, K, PRE).

15.15 If long lists of specimens are given, they must be listed together before Acknowledgements under the heading *Specimens examined*. They are arranged alphabetically by the collector's name and then numerically for each collector. The species is indicated in brackets by the number that was assigned to it in the text and any infraspecific taxa by a small letter. If more than one genus is dealt with in a given article, the first species of the first genus mentioned is indicated as 1.1. This is followed by the international herbarium designation. Note that the name of the collector and the collection number are italicized:

Acocks 12497 (2.1b) BM, K, PRE; 14724 (1.13a) BOL, K, P. *Archer 1507* (1.4) BM, *G. Burchell 2847* (2.8c) MB, K. *Burman 2401* (3.3) MO, S. *B.L. Burtt 789* (2.6) B, KMG, STE.

16 **Synonyms**

16.1 In a monograph or a revision covering all of southern Africa, all synonyms based on types of southern African origin, or used in southern African literature, should be included.

16.2 Illegitimate names are designated by *nom. illeg.* after the reference, followed by *non* with the author and date, if there is an earlier homonym.

16.3 Nomina nuda (*nom. nud.*) and invalidly published names are excluded unless there is a special reason to cite them, for example if they have been used in prominent publications.

16.4 In normal text, Latin words are italicized, but in the synopsis of a species Latin words such as *nom. nud.*, *et al.* are not italicized (see 13.5, 17.9).

16.5 Synonyms should be arranged chronologically into groups of nomenclatural synonyms, i.e. synonyms based on the same type, and the groups should be arranged chronologically by basionyms, except for the basionym of the correct name which is dealt with in the paragraph directly after that of the correct name.

16.6 When a generic name is repeated in a given synonymy it should be abbreviated to the initial, except where intervening references to other genera with the same initial could cause confusion (see 13.4).

17 **Description and example of species treatment**

17.1 Descriptions of all taxa of higher plants should, where possible, follow the sequence: Habit; sexuality; underground parts (if relevant). *Indumentum* (if it can be easily described for the whole plant). *Stems/branches. Bark. Leaves*: arrangement, petiole absent/present, pubescence; blade: shape, size, apex, base, margin; midrib: above/below, texture, colour; petiole; stipules. *Inflorescence*: type, shape, position; bracts/bracteoles, involucral bracts: inner, outer. *Flowers*: shape, sex. *Receptacle. Calyx. Corolla. Disc. Androecium. Gynoecium. Fruit. Seeds. Flowering time. Chromosome number (reference). Conservation status.* Figure (word written out in full) number.

17.2 As a rule, shape should be given before measurements.

17.3 In general, if an organ has more than one of the parts being described, use the plural, otherwise use the singular, for example, petals of a flower but blade of a leaf.

17.4 Language must be as concise as possible, using participles instead of verbs.

17.5 Dimension ranges should be cited as in 17.9.

17.6 Care must be exercised in the use of dashes and hyphens. A *hyphen* is a short stroke joining two syllables of a word, e.g. ovate-lanceolate or sea-green, with no space between the letter and the stroke. An *N-dash* (*en*) is a longer stroke commonly used instead of the word 'to' between numerals, '2–5 mm long' (do not use it between words but rather use the word 'to', e.g. 'ovate to lanceolate'; it is produced by typing three hyphens next to each other, or in MS Word the code is alt + 0150. An *M-dash* (*em*) is a stroke longer than an N-dash and is used variously, e.g. in front of a subspecific epithet instead of the full species name; it is produced by typing two hyphens next to one another, or in MS Word the code is alt + 0151.

17.7 The use of '±' is preferred to c. or ca when describing shape, measurements, dimensions, etc. (see 13.12).

17.8 The decimal point replaces the comma in all units of measurement, e.g. leaves 1.0–1.5 mm long.

17.9 Example:

1. **Englerophytum magalismontanum** (*Sond.*) *T.D.Penn.*, The genera of Sapotaceae: 252 (1991). Type: Gauteng, Magaliesberg, *Zeyher 1849* (S, holo.–BOL, photo.!).

Bequaertiodendron magalismontanum (Sond.) Heine & Hemsl.: 307 (1960); Codd: 72 (1964); Elsdon: 75 (1980).

Chrysophyllum magalismontanum Sond.: 721 (1850); Harv.: 812 (1867); Engl.: 434 (1904); Bottmar: 34 (1919). *Zeyherella magalismontana* (Sond.) Aubrév. & Pellegr.: 105 (1958); Justin: 97 (1973).

Chrysophyllum argyrophyllum Hiern: 721 (1850); Engl.: 43 (1904). *Boivinella argyrophylla* (Hiern) Aubrév. & Pellegr.: 37 (1958); Justin et al.: 98 (1973). Types: Angola, *Welwitsch 4828* (BM!, lecto., here designated; PRE!); Angola, *Welwitsch s.n.* (BM!).

Chrysophyllum wilmsii Engl.: 4, t. 16 (1904); Masonet: 77 (1923); Woodson: 244 (1937). *Boivinella wilmsii* (Engl.) Aubrév. & Pellegr.: 39 (1958); Justin: 99 (1973). Type: without locality and collector [B, holo.†; K!, P!, lecto., designated by Aubrév. & Pellegr.: 38 (1958), PRE!, S!, W!, Z!].

Bequaertiodendron fruticosa De Wild.: 37 (1923), non Bonpl.: 590 (1823); D.Bakker: 167 (1929); H.Fr.: 302 (1938); Davy: 640 (1954); Breytenbach: 117 (1959); Clausen: 720 (1968); Palmer: 34 (1969). Type: Mpumalanga, Tzaneen Dist., *Granville in Herb. Pillans K48625* (K, holo.!; G!, P!, PRE!, S!).

B. fragrans auct. non Oldemann: Glover: 149, t. 19 (1915); Henkel: 226 (1934); Stapelton: 6 (1954).

Illustrations: Harv.: 812 (1867); Henkel: t. 84 (1934?); Codd: 73 (1964); Palmer: 35 (1969).

Woody perennial; main branches up to 0.4 m long, erect or decumbent, grey woolly-felted, leafy. *Leaves* linear to oblanceolate, 3–10(–23) × 1.0–1.5(–4.0) mm, obtuse, base broad, half-clasping. *Heads* heterogamous, campanulate, 7–8 × 5 mm, solitary, sessile at tip of axillary shoots; involucral bracts in 5 or 6 series, inner exceeding flowers, tips subopaque, white, very acute. *Receptacle* nearly smooth. *Flowers* ± 23–30, 7–11 male, 16–21 bisexual, yellow, tipped pink. *Achenes* ± 0.75 mm long, elliptic. *Pappus* bristles very many, equalling corolla, scabridulous. *Flowering time*: September. *Chromosome number*: 2n = 22. Figure 23B.

18 New taxa

18.1 The name of a new taxon must be accompanied by at least a Latin diagnosis. Authors should not provide full-length Latin descriptions unless they have the required expertise in Latin at their disposal.

18.2 It is recommended that descriptions of new taxa be accompanied by a good illustration, **preferably a line drawing, or a photograph (second choice)** and a distribution map.

18.3 Example:

109. **Helichrysum jubilatum** *Hilliard*, sp. nov., *H. alsinoidei* DC. affinis, sed foliis ellipticis (nec spatulatis), inflorescentiis compositis a foliis non circumcinctis, floribus femineis numero quasi dimidium hermaphroditorum aequantibus (nec capitulis homogamis vel floribus femineis 1–3 tantum) distinguitur.

Herba annua e basi ramosa; caules erecti vel decumbentes, 100–250 mm longi, tenuiter albo-lanati, remote foliati. *Folia* plerumque 8–30 × 5–15 mm, sub capitulis minora, elliptica vel oblanceolata, obtusa vel acuta, mucronata, basi semi-amplexicauli, utrinque cano-lanato-arachnoidea. *Capitula* heterogama, campanulata, 3.5– 4.0 × 2.5 mm, pro parte maxima in paniculas cymosas terminales aggregata; capitula subterminalia interdum solitaria vel 2 vel 3 ad apices ramulorum nudorum ad 30 mm longorum. *Bracteae involucrales* 5-seriatae, gradatae, exteriores pellucidae, pallide stramineae, dorso lanatae, seriebus duabus interioribus subaequalibus et flores quasi aequantibus, apicibus obtusis opacis niveis vix radiantibus. *Receptaculum* fere laeve. *Flores* ± 35–41. *Achenia* 0.75 mm longa, pilis myxogenis praedita. *Pappi* setae multae, corollam aequantes, apicibus scabridis, basibus non cohaerentibus.

TYPE.—Northern Cape, 2817 (Vioolsdrif): Richtersveld, (–CC), ± 5 miles E of Lekkersing on road to Stinkfontein, kloof in hill south of road, annual, disc whitish, 7-11-1962, *Nordenstam 1823* (S, holo.; E, NH, PRE).

19 New provinces of South Africa (Oct. 1996)

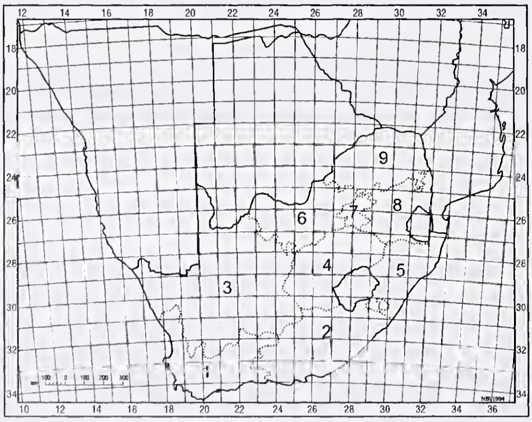

FIGURE 1.—1, Western Cape; 2, Eastern Cape; 3, Northern Cape; 4, Free State (previously Orange Free State); 5, KwaZulu-Natal (previously Natal); 6, North-West (previously northeastern Cape and southwestern Transvaal); 7, Gauteng (previously PWV); 8, Mpumalanga (previously Eastern Transvaal); 9, **Limpopo (previously Northern Transvaal, Northern Province).**

20 Proofs

Only page proofs are normally sent to authors. They should be corrected in red ink and be returned to the editor **as soon as possible**. Do not add any new information.

21 Reprints

Authors receive 100 reprints free. If there is more than one author, this number will have to be shared between them.

22 Documents consulted

Guides to authors of the following publications were made use of in the compilation of the present guide: *Annals of the Missouri Botanic Garden, Botanical Journal of the Linnean Society, Flora of Australia, Smithsonian Contributions to Botany, South African Journal of Botany* (including instructions to authors of taxonomic papers), *South African Journal of Science*.

23 Address of editor

Manuscripts should be submitted to: The Editor, Bothalia, National Botanical Institute, Private Bag X101, Pretoria 0001.

24 *FSA* contributions

24.1 Figures and text must conform to *Bothalia* format.

24.2 These articles will be considered as a full contribution to the *Flora of southern Africa* and will be listed as published in the '*Plan of Flora of southern Africa*', which appears in all issues of the *FSA* series.

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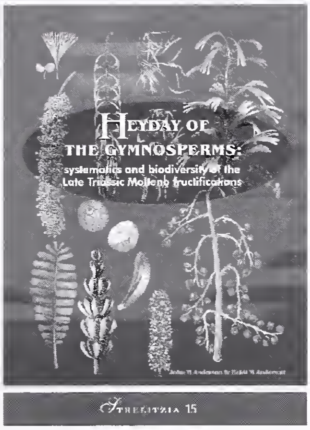


Strelitzia 15

Heyday of the gymnosperms: systematics and biodiversity of the Late Triassic Molteno fructifications

J.M. Anderson & H.M. Anderson (2003)

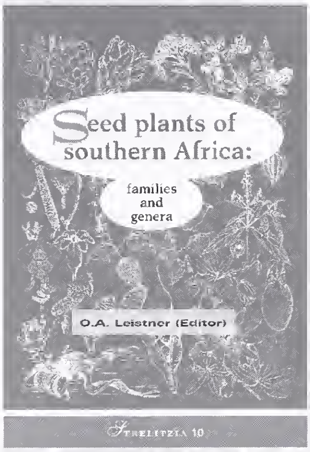
This book is based on extensive fieldwork and collections in the Karoo Basin of South Africa and provides the most comprehensive insight so far into extinct seed plants from the Mesozoic of the southern hemisphere. Large numbers of specimens have been used to delimit species and careful note has been taken of associations between different fossil species. A key feature is the focus on fossil seed plant reproductive structures, which are represented by 35 genera and more than 80 species. The book paints a vivid picture of the diversity of life in the Molteno flood plain 230 million years ago and documents the habitats in which modern groups such as mammals, conifers and beetles started to emerge. Richly illustrated with black-&-white line drawings, photographs, maps and diagrams. A4 size, pp. 398. Hard cover. ISBN 1-919795-98-7. **Price** SADC R250,00/other countries $54,00.

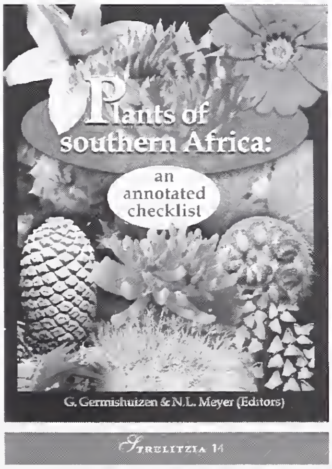
Strelitzia 10

Seed plants of southern Africa: families and genera

Edited by O.A. Leistner (2000)

Completely revised version of *The genera of southern African flowering plants* by R.A. Dyer (1975, 1976). A taxonomic treatment of some 227 seed plant families and about 2 180 indigenous and naturalized genera, with a key to the families and keys to the genera in each family. Alphabetical arrangement within: gymnosperms, dicotyledons and monocotyledons. Descriptions, chromosome numbers, notes on distribution and size, both local and worldwide. Literature references. Dendrograms reflecting latest views on relationships of families. Classification of genera within the larger families. Comprehensive glossary. A4 size, pp. 775. Hard cover. ISBN 1-919795-51-0. **Price** SADC R350.00/other countries $70.00.





Strelitzia 14

Plants of southern Africa: an annotated checklist (due in November 2003)

G. Germishuizen & N.L. Meyer (Editors)

Long-awaited update of Arnold & De Wet (1993): *Plants of southern Africa: names and distribution*. Expanded to include information on life cycle, habit, height of plant and altitude together with updated data on taxa, literature references, synonyms and regional distribution. Plant families grouped into seven more or less natural assemblages: Bryophyta, Hepatophyta, Anthocerotophyta, Pteridophyta, Gymnosperms, Dicotyledons and Monocotyledons. A4 size, 1230 pp.
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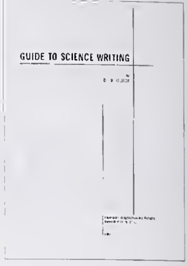

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